CHAPTER 6

AIRCRAFT HARDWARE, MATERIALS, AND PROCESSES

AIRCRAFT HARDWARE

Aircraft hardware is the term used to describe the various types of fasteners and miscellaneous small items used in the manufacture and repair of aircraft.

The importance of aircraft hardware is often overlooked because of its small size; however, the safe and efficient operation of any aircraft is greatly dependent upon the correct selection and use of aircraft hardware.

Identification

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

THREADED FASTENERS

Various types of fastening devices allow quick dismantling or replacement of aircraft parts that must be taken apart and put back together at frequent intervals. Riveting or welding these parts each time they are serviced would soon weaken or ruin the joint. Furthermore, some joints require greater tensile strength and stiffness than rivets can provide. Bolts and screws are two types of fastening devices which give the required security of attachment and rigidity. Generally, bolts are used where great strength is required, and screws are used where strength is not the deciding factor.

Bolts and screws are similar in many ways. They are both used for fastening or holding, and each has a head on one end and screw threads on the other. Regardless of these similarities, there are several distinct differences between the two types of fasteners. The threaded end of a bolt is always blunt while that of a screw may be either blunt or pointed.

The threaded end of a bolt usually has a nut screwed onto it to complete the assembly. The threaded end of a screw may fit into a female receptacle, or it may fit directly into the material being secured. A bolt has a fairly short threaded section and a comparatively long grip length or unthreaded portion, whereas a screw has a longer threaded section and may have no clearly defined grip length. A bolt assembly is generally tightened by turning the nut on the bolt; the head of the bolt may or may not be designed for turning. A screw is always tightened by turning its head.

When it becomes necessary to replace aircraft fasteners, a duplicate of the original fastener should be used if at all possible. If duplicate fasteners are not available, extreme care and caution must be used in selecting substitutes.

Classification of Threads

Aircraft bolts, screws, and nuts are threaded in either the NC (American National Coarse) thread series, the NF (American National Fine) thread series, the UNC (American Standard Unified Coarse) thread series, or the UNF (American Standard Unified Fine) thread series. There is one difference between the American National series and the American Standard Unified series that should be pointed out. In the 1-inch-diameter size, the NF thread specified 14 threads per inch (1–14NF), while the UNF thread specifies 12 threads per inch (1–12UNF). Both type threads are designated by the number of times the incline (threads) rotates around a 1-inch length of a given diameter bolt or screw. For example, a 4–28 thread indicates that a ¼-inch-diameter bolt has 28 threads in 1 inch of its threaded length.

Threads are also designated by Class of fit. The Class of a thread indicates the tolerance allowed in manufacturing. Class 1 is a loose fit, Class 2 is a free fit, Class 3 is a medium fit, and Class 4 is a close fit. Aircraft bolts are almost always manufactured in the Class 3, medium fit.

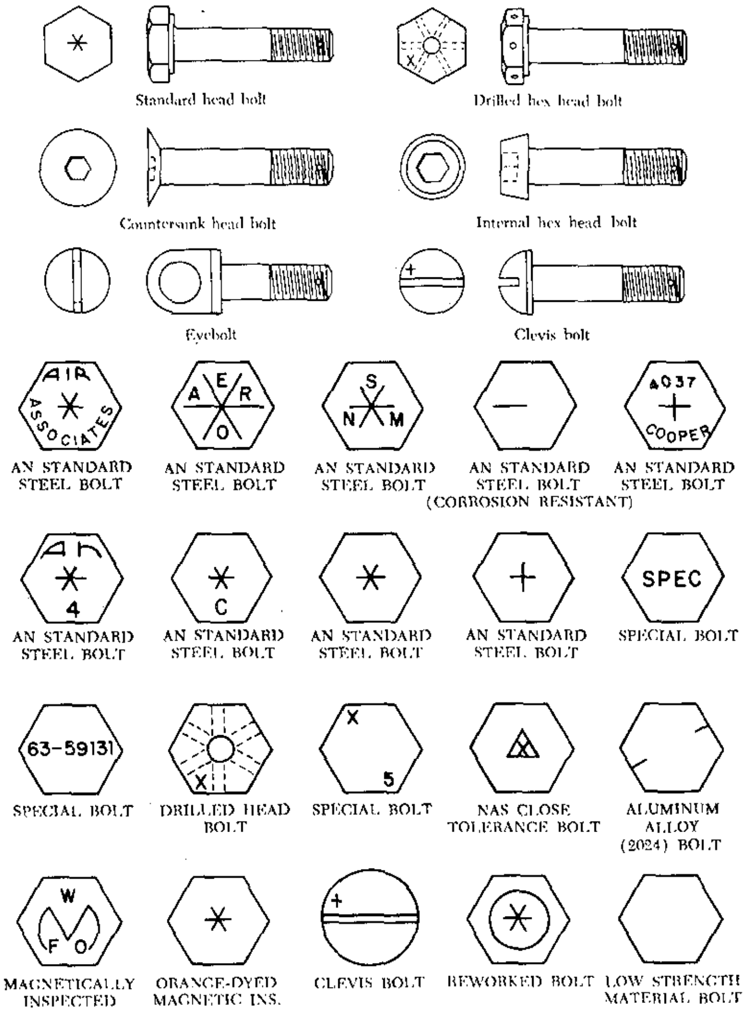


FIGURE 6–1. Aircraft bolt identification.

A Class 4 fit requires a wrench to turn the nut onto a bolt, whereas a Class 1 fit can easily be turned with the fingers. Generally, aircraft screws are manufactured with a Class 2 thread fit for ease of assembly.

Bolts and nuts are also produced with right-hand and left-hand threads. A right-hand thread tightens when turned clockwise; a left-hand thread tightens when turned counterclockwise.

AIRCRAFT BOLTS

Aircraft bolts are fabricated from cadmium- or zinc-plated corrosion-resistant steel, unplated corrosion-resistant steel, and anodized aluminum alloys. Most bolts used in aircraft structures are either general-purpose, AN bolts, or NAS internal-wrenching or close-tolerance bolts, or MS bolts. In certain cases, aircraft manufacturers make bolts of different dimensions or greater strength than the standard types. Such bolts are made for a particular application, and it is of extreme importance to use like bolts in replacement. Special bolts are usually identified by the letter "S" stamped on the head.

AN bolts come in three head styles—hex-head, clevis, and eyebolt (*see* figure 6–1). NAS bolts are available in hex-head, internal-wrenching, and countersunk head styles. MS bolts come in hex-head and internal-wrenching styles.

General-Purpose Bolts

The hex-head aircraft bolt (AN–3 through AN–20) is an all-purpose structural bolt used for general applications involving tension or shear loads where a light-drive fit is permissible (.006-inch clearance for a ⅝-inch hole, and other sizes in proportion).

Alloy steel bolts smaller than No. 10–32 and aluminum alloy bolts smaller than ¼-inch diameter are not used in primary structures. Aluminum alloy bolts and nuts are not used where they will be repeatedly removed for purposes of maintenance and inspection. Aluminum alloy nuts may be used with cadmium-plated steel bolts loaded in shear on land airplanes, but are not used on seaplanes due to the increased possibility of dissimilar-metal corrosion.

The AN-73 drilled-head bolt is similar to the standard hex-bolt, but has a deeper head which is drilled to receive wire for safetying. The AN-3 and the AN-73 series bolts are interchangeable, for all practical purposes, from the standpoint of tension and shear strengths.

Close-Tolerance Bolts

This type of bolt is machined more accurately than the general-purpose bolt. Close-tolerance bolts may be hex-headed (AN-173 through AN-186) or have a 100° countersunk head (NAS-80 through NAS-86). They are used in applications where a tight-drive fit is required (the bolt will move into position only when struck with a 12- to 14-ounce hammer).

Internal-Wrenching Bolts

These bolts, (MS-20004 through MS-20024 or NAS-495) are fabricated from high-strength steel and are suitable for use in both tension and shear applications. When they are used in steel parts, the bolthole must be slightly countersunk to seat the large corner radius of the shank at the head. In Dural material, a special heat-treated washer must be used to provide an adequate bearing surface for the head. The head of the internal-wrenching bolt is recessed to allow the insertion of an internal wrench when installing or removing the bolt. Special high-strength nuts are used on these bolts. Replace an internal-wrenching bolt with another internal-wrenching bolt. Standard AN hex-head bolts and washers cannot be substituted for them as they do not have the required strength.

Identification and Coding

Bolts are manufactured in many shapes and varieties. A clear-cut method of classification is difficult. Bolts can be identified by the shape of the head, method of securing, material used in fabrication, or the expected usage.

AN-type aircraft bolts can be identified by the code markings on the boltheads. The markings generally denote the bolt manufacturer, the material of which the bolt is made, and whether the bolt is a standard AN-type or a special-purpose bolt. AN standard steel bolts are marked with either a raised dash or asterisk; corrosion-resistant steel is indicated by a single raised dash; and AN aluminum alloy bolts are marked with two raised dashes. Additional information, such as bolt diameter, bolt length, and grip length may be obtained from the bolt part number.

For example, in the bolt part number AN3DD5A, the "AN" designates that it is an Air Force-Navy Standard bolt, the "3" indicates the diameter in sixteenths of an inch (3/16), the "DD" indicates the material is 2024 aluminum alloy. The letter "C" in place of the "DD" would indicate corrosion-resistant steel, and the absence of the letters would indicate cadmium-plated steel. The "5" indicates the length in eighths of an inch (5/8), and the "A" indicates that the shank is undrilled. If the letter "H" preceded the "5" in addition to the "A" following it, the head would be drilled for safetying.

Close-tolerance NAS bolts are marked with either a raised or recessed triangle. The material markings for NAS bolts are the same as for AN bolts, except that they may be either raised or recessed. Bolts inspected magnetically (Magnaflux) or by fluorescent means (Zyglo) are identified by means of colored lacquer, or a head marking of a distinctive type.

SPECIAL-PURPOSE BOLTS

Bolts designed for a particular application or use are classified as special-purpose bolts. Clevis bolts, eyebolts, Jo-bolts, and lock bolts are special-purpose bolts.

Clevis Bolts

The head of a clevis bolt is round and is either slotted to receive a common screwdriver or recessed to receive a crosspoint screwdriver. This type of bolt is used only where shear loads occur and never in tension. It is often inserted as a mechanical pin in a control system.

Eyebolt

This type of special-purpose bolt is used where external tension loads are to be applied. The eye is designed for the attachment of such devices as the fork of a turnbuckle, a clevis, or a cable shackle. The threaded end may or may not be drilled for safetying.

Jo-Bolt

Jo-bolt is a trade name for an internally threaded three-piece rivet. The Jo-bolt consists of three parts—a threaded steel alloy bolt, a threaded steel nut, and an expandable stainless steel sleeve. The parts are factory preassembled. As the Jo-bolt is installed, the bolt is turned while the nut is held. This causes the sleeve to expand over the end of the nut, forming the blind head and clamping against the work. When driving is complete, a portion of the bolt breaks off. The high-shear and tensile strength of the Jo-bolt makes it suitable for use in cases of high stresses where some of the other blind fasteners would not be practical. Jo-bolts are often a part of the permanent structure of late-model aircraft. They are used in areas which are not often subjected to replacement or servicing. (Because it is a three-part fastener, it should not be used where any part, in becoming loose, could be drawn into the engine air intake.) Other advantages of using Jo-bolts are their excellent resistance to vibration, weight saving, and fast installation by one person.

Presently, Jo-bolts are available in four diameters: The 200 series, approximately 3/16-inch in diameter; the 260 series, approximately 1/4-inch in diameter; the 312 series, approximately 5/16-inch in diameter; and the 375 series, approximately 3/8-inch in diameter. Jo-bolts are available in three head styles which are: F(flush), P(hex-head), and FA(flush millable).

Lockbolts

The lockbolt combines the features of a high-strength bolt and rivet, but it has advantages over both. The lockbolt is generally used in wing-splice fittings, landing-gear fittings, fuel-cell fittings, longerons, beams, skin-splice plates, and other major structural attachments. It is more easily and quickly installed than the conventional rivet or bolt and eliminates the use of lockwashers, cotter pins, and special nuts. Like the rivet, the lockbolt requires a pneumatic hammer or "pull gun" for installation; when installed, it is rigidly and permanently locked in place. Three types of lockbolts are commonly used, the pull type, the stump type, and the blind type. (See figure 6–2.)

Pull type. Pull-type lockbolts are used mainly in aircraft primary and secondary structures. They

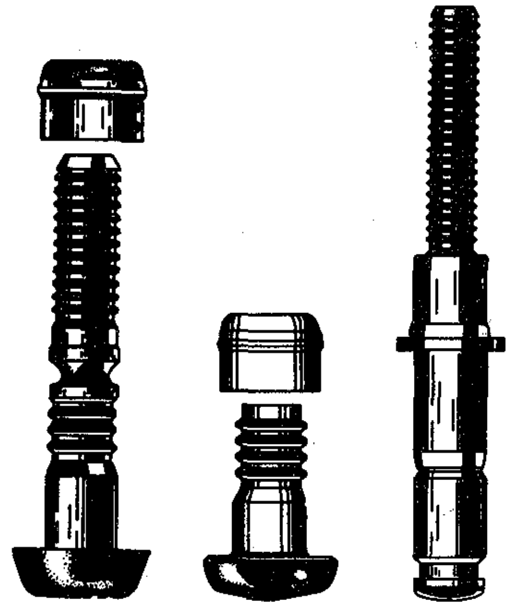


FIGURE 6–2. Lockbolt types.

are installed very rapidly and have approximately one-half the weight of equivalent AN steel bolts and nuts. A special pneumatic "pull gun" is required to install this type of lockbolt. Installation can be accomplished by one person since bucking is not required.

Stump type. Stump-type lockbolts, although they do not have the extended stem with pull grooves, are companion fasteners to pull-type lockbolts. They are used primarily where clearance will not permit installation of the pull-type lockbolt. A standard pneumatic riveting hammer (with a hammer set attached for swaging the collar into the pin-locking grooves) and a bucking bar are tools necessary for the installation of stump-type lockbolts.

Blind type. Blind-type lockbolts come as complete units or assemblies. They have exceptional strength and sheet pull-together characteristics. Blind lockbolts are used where only one side of the work is accessible and, generally, where it is difficult to drive a conventional rivet. This type of lockbolt is installed in the same manner as the pull-type lockbolt.

Common features. Common features of the three types of lockbolts are the annular locking grooves on the pin and the locking collar which is swaged into the pin's lock grooves to lock the pin in tension. The pins of the pull- and blind-type lockbolts are extended for pull installation. The extension is provided with pulling grooves and a tension breakoff groove.

Composition. The pins of pull- and stump-type lockbolts are made of heat-treated alloy steel or high-strength aluminum alloy. Companion collars are made of aluminum alloy or mild steel. The blind lockbolt consists of a heat-treated alloy steel pin, blind sleeve and filler sleeve, mild steel collar, and carbon steel washer.

Substitution. Alloy steel lockbolts may be used to replace steel hi-shear rivets, solid steel rivets, or AN bolts of the same diameter and head type. Aluminum alloy lockbolts may be used to replace solid aluminum alloy rivets of the same diameter and head type. Steel and aluminum alloy lockbolts may also be used to replace steel and 2024T aluminum alloy bolts, respectively, of the same diameter. Blind lockbolts may be used to replace solid aluminum alloy rivets, stainless steel rivets, or all blind rivets of the same diameter.

Numbering system. The numbering systems for the various types of lockbolts are explained by the following breakouts (see figure 6–4).

GRIP NO.	GRIP RANGE		GRIP NO.	GRIP RANGE	
	Min.	Max.		Min.	Max.
1	.031	.094	17	1.031	1.094
2	.094	.156	18	1.094	1.156
3	.156	.219	19	1.156	1.219
4	.219	.281	20	1.219	1.281
5	.281	.344	21	1.281	1.344
6	.344	.406	22	1.344	1.406
7	.406	.469	23	1.406	1.469
8	.469	.531	24	1.469	1.531
9	.531	.594	25	1.531	1.594
10	.594	.656	26	1.594	1.656
11	.656	.718	27	1.656	1.718
12	.718	.781	28	1.718	1.781
13	.781	.843	29	1.781	1.843
14	.843	.906	30	1.843	1.906
15	.906	.968	31	1.906	1.968
16	.968	1.031	32	1.968	2.031
			33	2.031	2.094

FIGURE 6–3. Pull- and stump-type lockbolt grip ranges.

Pull-type lockbolt—

ALPP H T 8 8

- Grip length in 16ths of an inch.
- Body diameter in 32nds of an inch.
- Pin materials—
  - E = 75S–T6 aluminum alloy.
  - T = heat-treated alloy steel.
- Class fit—
  - H = hole filling (interference fit).
  - N = non-hole filling (clearance fit).
- Head type—
  - ACT 509 = close tolerance AN–509 C-sink head.
  - ALPP = pan head.
  - ALPB = brazier head.
  - ALP509 = standard AN–509 C-sink head.
  - ALP426 = standard AN–426 C-sink head.

Blind-type lockbolt—

BL 8 4

- Grip length in 16ths of an inch, ±1/32 inch.
- Diameter in 32nds of an inch.
- Blind lockbolt.

Lockbolt collar—

LC C 8

- Diameter of pin in 32nds of an inch.
- *Material—
  - C = 24ST aluminum alloy (green color).
  - F = 61ST aluminum alloy (plain color).
  - R = mild steel (cadmium plated).
- Lockbolt collar.

* Use 25ST aluminum alloy with heat-treated alloy lockbolts only.
Use 61ST aluminum alloy with 75ST aluminum alloy lockbolts only.
Use mild steel with heat-treated alloy steel lockbolts for high temperature applications only.

Stump-type lockbolt—

ALSF E 8 8

- Grip length in 16ths of an inch.
- Body diameter in 32nds of an inch.
- Pin material—
  - E = 75S–T6 aluminum alloy.
  - T = heat-treated alloy steel.
- Head type—
  - ASCT509 = close tolerance AN–509 C-sink head.
  - ALSF = flat head type.
  - ALS509 = standard AN–509 C-sink head.
  - ALS426 = standard AN–426 C-sink head.

FIGURE 6–4. Lockbolt numbering system.

¼-inch Diameter			5/16-inch Diameter		
GRIP NO.	GRIP RANGE		GRIP NO.	GRIP RANGE	
	Min.	Max.		Min.	Max.
1	.031	.094	2	.094	.156
2	.094	.156	3	.156	.219
3	.156	.219	4	.219	.281
4	.219	.281	5	.281	.344
5	.281	.344	6	.344	.406
6	.344	.406	7	.406	.469
7	.406	.469	8	.469	.531
8	.469	.531	9	.531	.594
9	.531	.594	10	.594	.656
10	.594	.656	11	.656	.718
11	.656	.718	12	.718	.781
12	.718	.781	13	.781	.843
13	.781	.843	14	.843	.906
14	.843	.906	15	.906	.968
15	.906	.968	16	.968	1.031
16	.968	1.031	17	1.031	1.094
17	1.031	1.094	18	1.094	1.156
18	1.094	1.156	19	1.156	1.219
19	1.156	1.219	20	1.219	1.281
20	1.219	1.281	21	1.281	1.343
21	1.281	1.343	22	1.343	1.406
22	1.343	1.406	23	1.406	1.469
23	1.406	1.469	24	1.460	1.531
24	1.469	1.531			
25	1.531	1.594			

FIGURE 6–5. Blind-type lockbolt grip ranges.

Grip Range. The bolt grip range required for any application should be determined by measuring the thickness of the material with a hook scale inserted through the hole. Once this measurement is determined the correct grip range can be selected by referring to the charts provided by the rivet manufacturer. Examples of grip-range charts are shown in figures 6–3 and 6–5.

When installed, the lockbolt collar should be swaged substantially throughout the complete length of the collar. The tolerance of the broken end of the pin relative to the top of the collar must be within the following dimensions:

Pin diameter	Tolerance Below		Above
3/16	.079	to	.032
¼	.079	to	.050
5/16	.079	to	.050
⅜	.079	to	.060

When removal of a lockbolt becomes necessary, remove the collar by splitting it axially with a sharp, cold chisel. Be careful not to break out or deform the hole. The use of a backup bar on the opposite side of the collar being split is recommended. The pin may then be driven out with a drift punch.

AIRCRAFT NUTS

Aircraft nuts are made in a variety of shapes and sizes. They are made of cadmium-plated carbon steel, stainless steel, or anodized 2024T aluminum alloy, and may be obtained with either right- or left-hand threads. No identifying marking or lettering appears on nuts. They can be identified only by the characteristic metallic luster or color of the aluminum, brass, or the insert when the nut is of the self-locking type. They can be further identified by their construction.

Aircraft nuts can 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. Self-locking nuts contain the locking feature as an integral part.

Non-self-locking Nuts

Most of the familiar types of nuts, including the plain nut, the castle nut, the castellated shear nut, the plain hex nut, the light hex nut, and the plain check nut are the non-self-locking type. (See figure 6–6.)

The castle nut, AN310, is used with drilled-shank AN hex head bolts, clevis bolts, eyebolts, drilled head bolts, or studs. It is fairly rugged and can withstand large tensional loads. Slots (called castellations) in the nut are designed to accommodate a cotter pin or lock wire for safety.

The castellated shear nut, AN320, is designed for use with devices (such as drilled clevis bolts and threaded taper pins) which are normally subjected to shearing stress only. Like the castle nut, it is castellated for safetying. Note, however, that the nut is not as deep or as strong as the castle nut; also that the castellations are not as deep as those in the castle nut.

The plain hex nut, AN315 and AN335 (fine and coarse thread), is of rugged construction. This makes it suitable for carrying large tensional loads. However, since it requires an auxiliary locking device such as a check nut or lockwasher, its use on aircraft structures is somewhat limited.

The light hex nut, AN340 and AN345 (fine and coarse thread), is a much lighter nut than the plain hex nut and must be locked by an auxiliary

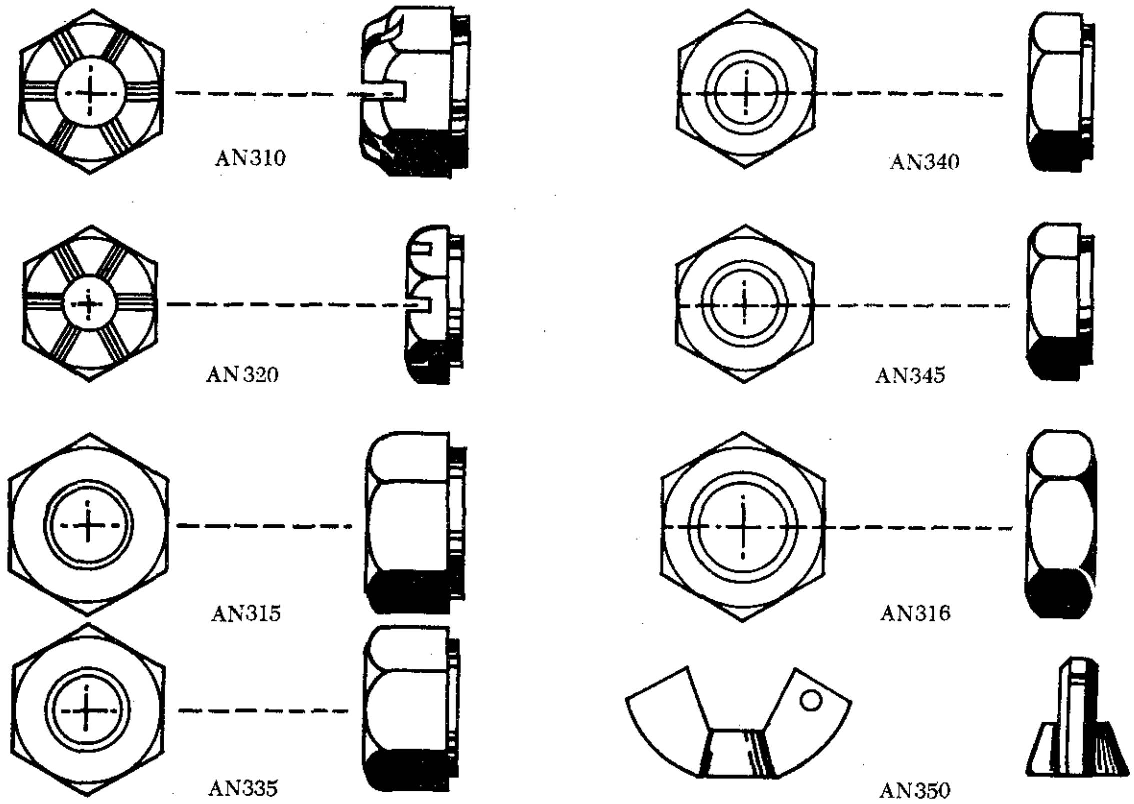


FIGURE 6–6. Non-self-locking nuts.

device. It is used for miscellaneous light-tension requirements.

The plain check nut, AN316, is employed as a locking device for plain nuts, set screws, threaded rod ends, and other devices.

The wing nut, AN350, is intended for use where the desired tightness can be obtained with the fingers and where the assembly is frequently removed.

Self-Locking Nuts

As their name implies, self-locking nuts need no auxiliary means of safetying but have a safetying feature included as an integral part of their construction. Many types of self-locking nuts have been designed and their use has become quite widespread. Common applications are: (1) Attachment of antifriction bearings and control pulleys; (2) Attachment of accessories, anchor nuts around inspection holes and small tank installation openings; and (3) Attachment of rocker box covers and exhaust stacks. Self-locking nuts are acceptable for use on certificated aircraft subject to the restrictions of the manufacturer.

Self-locking nuts are used on aircraft to provide tight connections which will not shake loose under severe vibration. Do not use self-locking nuts at joints which subject either the nut or bolt to rotation. They may be used with antifriction bearings and control pulleys, provided the inner race of the bearing is clamped to the supporting structure by the nut and bolt. Plates must be attached to the structure in a positive manner to eliminate rotation or misalignment when tightening the bolts or screws.

The two general types of self-locking nuts currently in use are the all-metal type and the fiber-lock type. For the sake of simplicity, only three typical kinds of self-locking nuts are considered in this handbook: The Boots self-locking and the stainless steel self-locking nuts, representing the all-metal types; and the elastic stop nut, representing the fiber-insert type.

Boots Self-Locking Nut

The Boots self-locking nut is of one-piece, all-metal construction, designed to hold tight in spite of severe vibration. Note in figure 6–7 that it has two sections and is essentially two nuts in one, a locking nut and a load-carrying nut. The two sections are connected with a spring which is an integral part of the nut. The spring keeps the locking and load-carrying sections such a distance

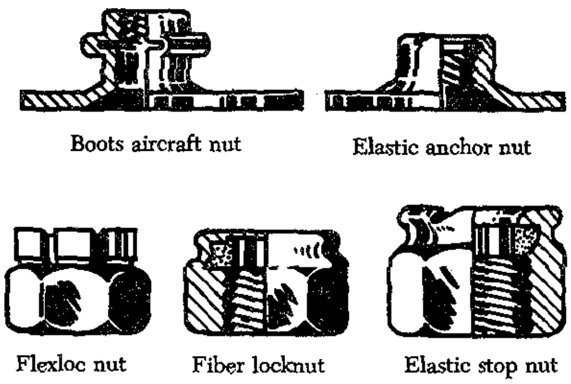


FIGURE 6–7. Self-locking nuts.

apart that the two sets of threads are out-of-phase; that is, so spaced that a bolt which has been screwed through the load-carrying section must push the locking section outward against the force of the spring to engage the threads of the locking section properly.

Thus, the spring, through the medium of the locking section, exerts a constant locking force on the bolt in the same direction as a force that would tighten the nut. In this nut, the load-carrying section has the thread strength of a standard nut of comparable size, while the locking section presses against the threads of the bolt and locks the nut firmly in position. Only a wrench applied to the nut will loosen it. The nut can be removed and reused without impairing its efficiency.

Boots self-locking nuts are made with three different spring styles and in various shapes and sizes. The wing type, which is the most common, ranges in size for No. 6 up to $1/4$ inch, the Rol-top ranges from $1/4$ inch to $9/16$ inch, and the bellows type ranges in size from No. 8 up to $3/8$ inch. Wing-type nuts are made of anodized aluminum alloy, cadmium plated carbon steel, or stainless steel. The Rol-top nut is cadmium-plated steel, and the bellows type is made of aluminum alloy only.

Stainless Steel Self-Locking Nut

The stainless steel self-locking nut may be spun on and off with the fingers, as its locking action takes place only when the nut is seated against a solid surface and tightened. The nut consists of two parts; a case with a beveled locking shoulder and key, and a threaded insert with a locking shoulder and slotted keyway. Until the nut is tightened it spins on the bolt easily, because the threaded insert is the proper size for the bolt. However, when the nut is seated against a solid surface and tightened, the locking shoulder of the insert is pulled downward and wedged against the locking shoulder of the case. This action compresses the threaded insert and causes it to clench the bolt tightly. The cross-sectional view in figure 6–8 shows how the key of the case fits into the slotted keyway of the insert so that when the case is turned the threaded insert is turned with it. Note that the slot is wider than the key. This permits the slot to be narrowed and the insert to be compressed when the nut is tightened.

Elastic Stop Nut

The elastic stop nut is a standard nut with the height increased to accommodate a fiber-locking collar. This fiber collar is very tough and durable and is unaffected by immersion in hot or cold water or ordinary solvents such as ether, carbon tetrachloride, oils, and gasoline. It will not damage bolt threads or plating.

As shown in figure 6–9, the fiber-locking collar is not threaded and its inside diameter is smaller than the largest diameter of the threaded portion or the outside diameter of a corresponding bolt. When the nut is screwed onto a bolt, it acts as an ordinary nut until the bolt reaches the fiber collar. When the bolt is screwed into the fiber collar, however, friction (or drag) causes the fiber to be pushed upward. This creates a heavy downward pressure on the load-carrying part and automatically throws the load-carrying sides of the nut and bolt threads into positive contact. After the bolt has been forced all the way through the fiber collar, the downward pressure remains constant. This pressure locks and holds the nut securely in place even under severe vibration.

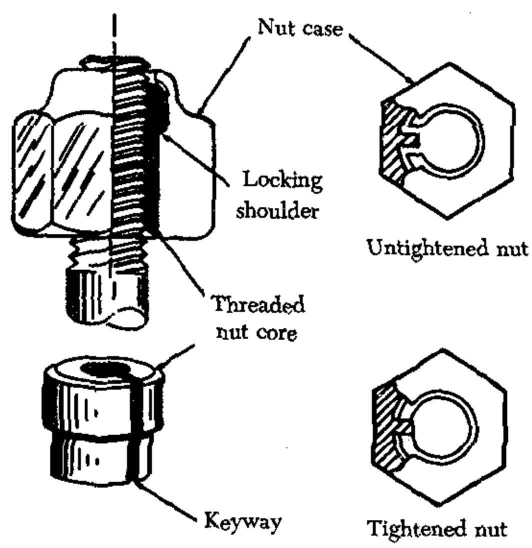


FIGURE 6–8. Stainless steel self-locking nut.

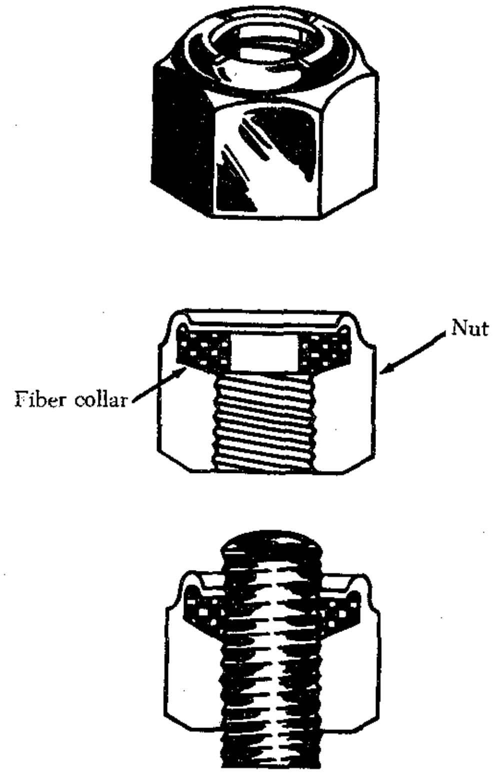


FIGURE 6–9. Elastic stop nut.

Nearly all elastic stop nuts are steel or aluminum alloy. However, such nuts are available in practically any kind of metal. Aluminum alloy elastic stop nuts are supplied with an anodized finish. Steel nuts are cadmium plated.

Normally, elastic stop nuts can be used many times with complete safety and without detriment to their locking efficiency. When reusing elastic stop nuts, be sure the fiber has not lost its locking friction or become brittle. If a nut can be turned with the fingers, replace it.

After the nut has been tightened, make sure the rounded or chamfered end of the bolts, studs, or screws extends at least the full round or chamfer through the nut. Flat end bolts, studs, or screws should extend at least $\frac{1}{32}$ inch through the nut. Bolts of $\frac{5}{16}$-inch diameter and over with cotter pin holes may be used with self-locking nuts, but only if free from burrs around the holes. Bolts with damaged threads and rough ends are not acceptable. Do not tap the fiber-locking insert. The self-locking action of the elastic stop nut is the result of having the bolt threads impress themselves into the untapped fiber.

Do not install elastic stop nuts in places where the temperature is higher than 250° F., because the effectiveness of the self-locking action is reduced beyond this point. Self-locking nuts may be used on aircraft engines and accessories when their use is specified by the engine manufacturer.

Self-locking nut bases are made in a number of forms and materials for riveting and welding to aircraft structure or parts. (See figure 6–10.) Certain applications require the installation of self-locking nuts in channels, an arrangement which permits the attachment of many nuts with only a few rivets. These channels are track-like bases with regularly spaced nuts which are either removable or nonremovable. The removable type carries a floating nut, which can be snapped in or out of the channel, thus making possible the easy removal of damaged nuts. Nuts such as the clinch-type and spline-type which depend on friction for their anchorage are not acceptable for use in aircraft structures.

Sheet Spring Nuts

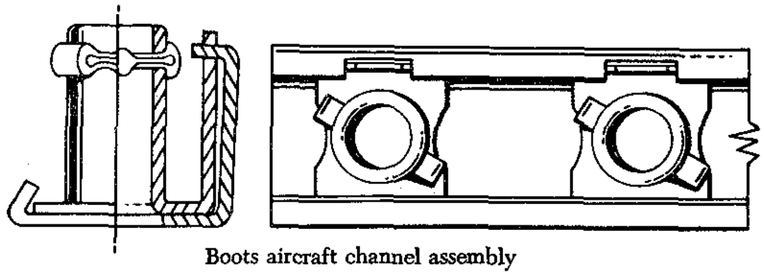
Sheet spring nuts, such as speed nuts, are used with standard and sheet-metal self-tapping screws in nonstructural locations. They find various uses in supporting line clamps, conduit clamps, electrical equipment, access doors, and the like, and are available in several types. Speed nuts are made from spring steel and are arched prior to tightening. This arched spring lock prevents the screw from working loose. These nuts should be used only where originally used in the fabrication of the aircraft.

Internal and External Wrenching Nuts

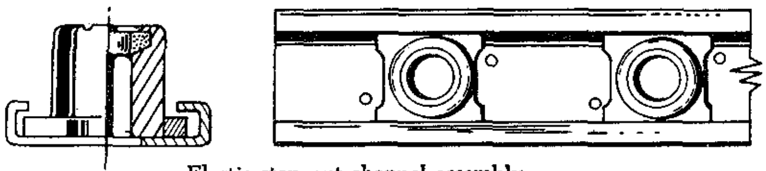
Two commercial types of high-strength internal or external wrenching nuts are available; they are the internal and external wrenching elastic-stop nut and the Unbrako internal and external wrenching nut. Both are of the self-locking type, are heat-treated, and are capable of carrying high-strength bolt-tension loads.

Identification and Coding

Part numbers designate the type of nut. The common types and their respective part numbers are: Plain, AN315 and AN335; castle AN310;



Boots aircraft channel assembly



Elastic stop nut channel assembly

FIGURE 6–10. Self-locking nut bases.

plain check, AN316; light hex, AN340 and AN345; and castellated shear, AN320. The patented self-locking types are assigned part numbers ranging from MS20363 through MS20367. The Boots, the Flexloc, the fiber locknut, the elastic stop nut, and the self-locking nut belong to this group. Part number AN350 is assigned to the wing nut.

Letters and digits following the part number indicate such items as material, size, threads per inch, and whether the thread is right or left hand. The letter "B" following the part number indicates the nut material to be brass; a "D" indicates 2017-T aluminum alloy; a "DD" indicates 2024-T aluminum alloy; a "C" indicates stainless steel; and a dash in place of a letter indicates cadmium-plated carbon steel.

The digit (or two digits) following the dash or the material code letter is the dash number of the nut, and it indicates the size of the shank and threads per inch of the bolt on which the nut will fit. The dash number corresponds to the first figure appearing in the part number coding of general-purpose bolts. A dash and the number 3, for example, indicates that the nut will fit an AN3 bolt (10–32); a dash and the number 4 means it will fit an AN4 bolt (1/4–28); a dash and the number 5, an AN5 bolt (5/16–24); and so on.

The code numbers for self-locking nuts end in three- or four-digit numbers. The last two digits refer to threads per inch, and the one or two preceding digits stand for the nut size in 16ths of an inch.

Some other common nuts and their code numbers are:

Code Number AN310D5R:

AN310 = aircraft castle nut.
D = 2024-T aluminum alloy.
5 = 5/16-inch diameter.
R = right-hand thread (usually 24 threads per inch).

Code Number AN320–10:

AN320 = aircraft castellated shear nut, cadmium-plated carbon steel.
10 = 5/8-inch diameter, 18 threads per inch (this nut is usually right-hand thread).

Code Number AN350B1032:

AN350 = aircraft wingnut.
B = brass.
10 = number 10 bolt.
32 = threads per inch.

AIRCRAFT WASHERS

Aircraft washers used in airframe repair are either plain, lock, or special type washers.

Plain Washers

Plain washers (figure 6–11), both the AN960 and AN970, are used under hex nuts. They provide a smooth bearing surface and act as a shim

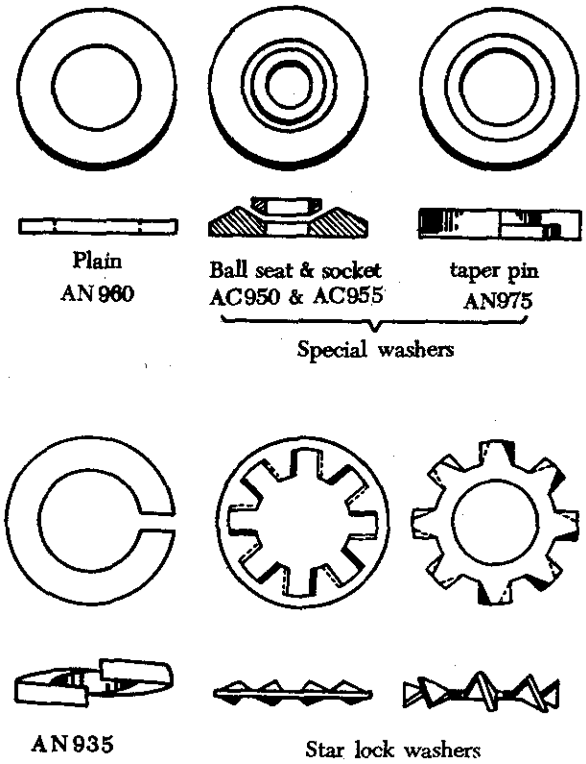


FIGURE 6–11. Various types of washers.

in obtaining correct grip length for a bolt and nut assembly. They are used to adjust the position of castellated nuts in respect to drilled coterr pin holes in bolts. Plain washers should be used under lockwashers to prevent damage to the surface material.

Aluminum and aluminum alloy washers may be used under boltheads or nuts on aluminum alloy or magnesium structures where corrosion caused by dissimilar metals is a factor. When used in this manner, any electric current flow will be between the washer and the steel bolt. However, it is common practice to use a cadmium-plated steel washer under a nut bearing directly against a structure as this washer will resist the cutting action of a nut better than an aluminum alloy washer.

The AN970 steel washer provides a greater bearing area than the AN960 washer and is used on wooden structures under both the head and the nut of a bolt to prevent crushing the surface.

Lockwashers

Lockwashers, both the AN935 and AN936, are used with machine screws or bolts where the self-locking or castellated type nut is not appropriate. The spring action of the washer (AN935) provides enough friction to prevent loosening of the nut from vibration. (These washers are shown in figure 6–11.)

Lockwashers should never be used under the following conditions:

1. With fasteners to primary or secondary structures.
2. With fasteners on any part of the aircraft where failure might result in damage or danger to the aircraft or personnel.
3. Where failure would permit the opening of a joint to the airflow.
4. Where the screw is subject to frequent removal.
5. Where the washers are exposed to the airflow.
6. Where the washers are subject to corrosive conditions.
7. Where the washer is against soft material without a plain washer underneath to prevent gouging the surface.

Shakeproof Lockwashers

Shakeproof lockwashers are round washers designed with tabs or lips that are bent upward across the sides of a hex nut or bolt to lock the nut in place. There are various methods of securing the lockwasher to prevent it from turning, such as an external tab bent downward 90° into a small hole in the face of the unit, or an internal tab which fits a keyed bolt.

Shakeproof lockwashers can withstand higher heat than other methods of safetying and can be used under high-vibration conditions safely. They should be used only once because the tabs tend to break when bent a second time.

Special Washers

The ball-socket and seat washers, AC950 and AC955, are special washers used where a bolt is installed at an angle to a surface, or where perfect alignment with a surface is required. These washers are used together. They are shown in figure 6–11.

The NAS143 and MS20002 washers are used for internal wrenching bolts of the NAS144 through NAS158 series. This washer is either plain or countersunk. The countersunk washer (designated as NAS143C and MS20002C) is used to seat the bolt head shank radius, and the plain washer is used under the nut.

INSTALLATION OF NUTS AND BOLTS

Bolt and Hole Sizes

Slight clearances in boltholes are permissible wherever bolts are used in tension and are not subject to reversal of load. A few of the applications in which clearance of holes may be permitted are in pulley brackets, conduit boxes, lining trim, and miscellaneous supports and brackets.

Boltholes are to be normal to the surface involved to provide full bearing surface for the bolthead and nut and must not be oversized or elongated. A bolt in such a hole will carry none of its shear load until parts have yielded or deformed enough to allow the bearing surface of the oversized hole to contact the bolt. In this respect, remember that bolts do not become swaged to fill up the holes as do rivets.

In cases of oversized or elongated holes in critical members, obtain advice from the aircraft or engine manufacturer before drilling or reaming the hole to take the next larger bolt. Usually, such factors as edge distance, clearance, or load factor must be considered. Oversized or elongated holes in noncritical members can usually be drilled or reamed to the next larger size.

Many boltholes, particularly those in primary connecting elements, have close tolerances. Generally, it is permissible to use the first lettered drill size larger than the normal bolt diameter, except where the AN hexagon bolts are used in light-drive fit (reamed) applications and where NAS close-tolerance bolts or AN clevis bolts are used.

Light-drive fits for bolts (specified on the repair drawings as .0015-inch maximum clearance between bolt and hole) are required in places where bolts are used in repair, or where they are placed in the original structure.

The fit of holes and bolts cannot be defined in terms of shaft and hole diameters; it is defined in terms of the friction between bolt and hole when sliding the bolt into place. A tight-drive fit, for example, is one in which a sharp blow of a 12- or 14-ounce hammer is required to move the bolt. A bolt that requires a hard blow and sounds tight is considered to fit too tightly. A light-drive fit is one in which a bolt will move when a hammer handle is held against its head and pressed by the weight of the body.

Installation Practices

Examine the markings on the bolthead to determine that each bolt is of the correct material. It is of extreme importance to use like bolts in replacement. In every case, refer to the applicable Maintenance Instructions Manual and Illustrated Parts Breakdown.

Be sure that washers are used under both the heads of bolts and nuts unless their omission is specified. A washer guards against mechanical damage to the material being bolted and prevents corrosion of the structural members. An aluminum alloy washer should be used under the head and nut of a steel bolt securing aluminum alloy or magnesium alloy members. Any corrosion that occurs then attacks the washer rather than the members. Steel washers should be used when joining steel members with steel bolts.

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

Be certain that the bolt grip length is correct. Grip length is the length of the unthreaded portion of the bolt shank. Generally speaking, the grip length should equal the thickness of the material being bolted together. However, bolts of slightly greater grip length may be used if washers are placed under the nut or the bolthead. In the case of plate nuts, add shims under the plate.

Safetying of Bolts and Nuts

It is very important that all bolts or nuts, except the self-locking type, be safetied after installation. This prevents them from loosening in flight due to vibration. Methods of safetying are discussed later in this chapter.

TORQUE AND TORQUE WRENCHES

As the speed of an aircraft increases, each structural member becomes more highly stressed. It is therefore extremely important that each member carry no more and no less than the load for which it was designed. In order to distribute the loads safely throughout a structure, it is necessary that proper torque be applied to all nuts, bolts, studs and screws. Using the proper torque allows the structure to develop its designed strength and greatly reduces the possibility of failure due to fatigue.

Torque Wrenches

The three most commonly used torque wrenches are the flexible beam, rigid frame, and the ratchet types (figure 6–12). When using the flexible beam and the rigid frame torque wrenches, the torque value is read visually on a dial or scale mounted on the handle of the wrench.

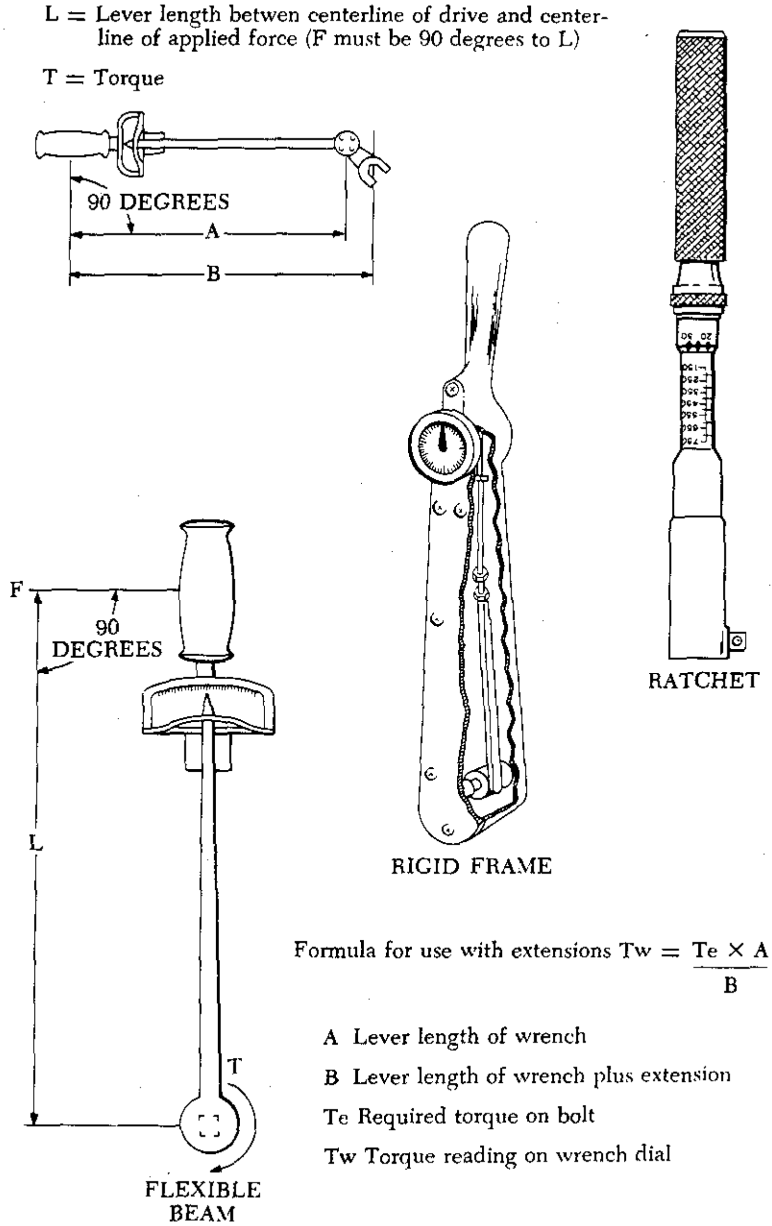
To use the ratchet type, unlock the grip and adjust the handle to the desired setting on the micrometer type scale, then relock the grip. Install the required socket or adapter to the square drive of the handle. Place the wrench assembly on the nut or bolt and pull the wrench assembly on the nut or bolt 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 applied torque reaches the torque value which indicated on the handle setting, the handle will automatically release or "break" and move

Basic formula $F \times L = T$

F = Applied force

L = Lever length betwen centerline of drive and centerline of applied force (F must be 90 degrees to L)

T = Torque



Formula for use with extensions $Tw = \frac{Te \times A}{B}$

A Lever length of wrench

B Lever length of wrench plus extension

Te Required torque on bolt

Tw Torque reading on wrench dial

FIGURE 6–12. Common torque wrenches.

Bolt, Stud or Screw Size		Torque Values in Inch-Pounds for Tightening Nuts			
		On standard bolts, studs, and screws having a tensile strength of 125,000 to 140,000 p.s.i.		On bolts, studs, and screws having a tensile strength of 140,000 to 160,000 p.s.i.	On high-strength bolts, studs, and screws having a tensile strength 160,000 p.s.i. and over
		Shear type nuts (AN320, AN364 or equivalent)	Tension type nuts and threaded machine parts (AN-310,AN365 or equivalent)	Any nut, except, shear type	Any nut, except shear type
8-32	8-36	7-9	12-15	14-17	15-18
10-24	10-32	12-15	20-25	23-30	25-35
1/4-20		25-30	40-50	45-49	50-68
	1/4-28	30-40	50-70	60-80	70-90
5/16-18		48-55	80-90	85-117	90-144
	5/16-24	60-85	100-140	120-172	140-203
3/8-16		95-110	160-185	173-217	185-248
	3/8-24	95-110	160-190	175-271	190-351
7/16-14		140-155	235-255	245-342	255-428
	7/16-20	270-300	450-500	475-628	500-756
1/2-13		240-290	400-480	440-636	480-792
	1/2-20	290-410	480-690	585-840	690-990
9/16-12		300-420	500-700	600-845	700-990
	9/16-18	480-600	800-1,000	900-1,220	1,000-1,440
5/8-11		420-540	700-900	800-1,125	900-1,350
	5/8-18	660-780	1,100-1,300	1,200-1,730	1,300-2,160
3/4-10		700-950	1,150-1,600	1,380-1,925	1,600-2,250
	3/4-16	1,300-1,500	2,300-2,500	2,400-3,500	2,500-4,500
7/8-9		1,300-1,800	2,200-3,000	2,600-3,570	3,000-4,140
	7/8-14	1,500-1,800	2,500-3,000	2,750-4,650	3,000-6,300
1"-8		2,200-3,000	3,700-5,000	4,350-5,920	5,000-6,840
	1"-14	2,200-3,300	3,700-5,500	4,600-7,250	5,500-9,000
1 1/8-8		3,300-4,000	5,500-6,500	6,000-8,650	6,500-10,800
	1 1/8-12	3,000-4,200	5,000-7,000	6,000-10,250	7,000-13,500
1 1/4-8		4,000-5,000	6,500-8,000	7,250-11,000	8,000-14,000
	1 1/4-12	5,400-6,600	9,000-11,000	10,000-16,750	11,000-22,500

FIGURE 6–13. Standard torque table (inch-pounds).

freely for a short distance. The release and free travel is easily felt, so there is no doubt about when the torquing process is completed.

To assure getting the correct amount of torque on the fasteners, all torque wrenches must be tested at least once a month or more often if necessary.

NOTE: It is not advisable to use a handle extension on a flexible beam type torque wrench at any time. A handle extension alone has no effect on the reading of the other types. The use of a drive-end extension on any type of torque wrench makes the use of the formula mandatory. When applying the formula, 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.

Torque Tables

The standard torque table should be used as a guide in tightening nuts, studs, bolts, and screws whenever specific torque values are not called out in maintenance procedures. The following rules apply for correct use of the torque table (figure 6–13):

1. To obtain values in foot-pounds, divide inch-pounds by 12.
2. Do not lubricate nuts or bolts except for corrosion-resistant steel parts or where specifically instructed to do so.
3. Always tighten by rotating the nut first if possible. When space considerations make it necessary to tighten by rotating the bolthead, approach the high side of the indicated torque range. Do not exceed the maximum allowable torque value.
4. 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.
5. For corrosion-resisting steel nuts, use torque values given for shear type nuts.
6. 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 standard torque range tables. When using a drive-end extension, the torque wrench reading must be computed by use of the proper formula, which is included in the handbook accompanying the torque wrench.

Cotter Pin Hole Line-Up

When tightening castellated nuts on bolts, the cotter pin holes may not line up with the slots in the nuts for the range of recommended values. Except in cases of highly stressed engine parts, the nut may be over tightened to permit lining up the next slot with the cotter pin hole. The torque loads specified may be used for all unlubricated cadmium-plated steel nuts of the fine- or coarse-thread series which have approximately equal number of threads and equal face bearing areas. These values do not apply where special torque requirements are specified in the maintenance manual.

If the head end, rather than the nut, must be turned in the tightening operation, maximum torque values may be increased by an amount equal to shank friction, provided the latter is first measured by a torque wrench.

AIRCRAFT SCREWS

Screws are the most commonly used threaded fastening devices on aircraft. They differ from bolts inasmuch as they are generally made of lower strength materials. They can be installed with a loose-fitting thread, and the head shapes are made to engage a screwdriver or wrench. Some screws have a clearly defined grip or unthreaded portion while others are threaded along their entire length.

Several types of structural screws differ from the standard structural bolts only in head style. The material in them is the same, and a definite grip length is provided. The AN525 washer-head screw and the NAS220 through NAS227 series are such screws.

Commonly used screws are classified in three groups: (1) Structural screws which have the same strength as equal size bolts; (2) machine screws, which include the majority of types used for general repair; and (3) self-tapping screws, which are used for attaching lighter parts. A fourth group, drive screws, are not actually screws but nails. They are driven into metal parts with a mallet or hammer and their heads are not slotted or recessed.

Structural Screws

Structural screws are made of alloy steel, are properly heat treated, and can be used as structural bolts. These screws are found in the NAS204 through NAS235 and AN509 and AN525 series. They have a definite grip and the same shear strength as a bolt of the same size. Shank tolerances are similar to AN hex-head bolts, and the threads are National Fine. Structural screws are available with round, brazier, or countersunk heads. The recessed head screws are driven by either a Phillips or a Reed and Prince screwdriver.

The AN509 (100°) flathead screw is used in countersunk holes where a flush surface is necessary.

The AN525 washer-head structural screw is used where raised heads are not objectionable. The washer-head screw provides a large contact area.

Machine Screws

Machine screws are usually of the flathead (countersunk), roundhead, or washer-head types. These screws are general-purpose screws and are available in low-carbon steel, brass, corrosion-resistant steel, and aluminum alloy.

Roundhead screws, AN515 and AN520, have either slotted or recessed heads. The AN515 screw has coarse threads and the AN520 has fine threads.

Countersunk machine screws are listed as AN505 and AN510 for 82°, and AN507 for 100°. The AN505 and AN510 correspond to the AN515 and AN520 roundhead in material and usage.

The fillister-head screw, AN500 through AN503, is a general-purpose screw and is used as a capscrew in light mechanisms. This could include attachments of cast aluminum parts such as gearbox cover plates.

The AN500 and AN501 screws are available in low-carbon steel, corrosion-resistant steel, and brass. The AN500 has coarse threads while the AN501 has fine threads. They have no clearly defined grip length. Screws larger than No. 6 have a hole drilled through the head for safetying purposes.

The AN502 and AN503 fillister-head screws are made of heat-treated alloy steel, have a small grip, and are available in fine and coarse threads. These screws are used as capscrews where great strength is required. The coarse-threaded screws are commonly used as capscrews in tapped aluminum alloy and magnesium castings because of the softness of the metal.

Self-tapping Screws

Machine self-tapping screws are listed as AN504 and AN506. The AN504 screw has a roundhead, and the AN506 is 82° countersunk. These screws are used for attaching removable parts, such as nameplates, to castings and parts in which the screw cuts its own threads.

AN530 and AN531 self-tapping sheet-metal screws, such as the Parker-Kalon Z-type sheet-metal screw, are blunt on the end. They are used in the temporary attachment of sheet metal for riveting, and in the permanent assembly of nonstructural assemblies. Self-tapping screws should not be used to replace standard screws, nuts, bolts, or rivets.

Drive Screws

Drive screws, AN535, correspond to the Parker-Kalon U-type. They are plain-head self-tapping screws used as capscrews for attaching nameplates in castings and for sealing drain holes in corrosion proofing tubular structures. They are not intended to be removed after installation.

Identification and Coding

The coding system used to identify screws is similar to that used for bolts. There are AN and NAS screws. NAS screws are structural screws. Part numbers 510, 515, 550, and so on, catalog screws into classes such as roundhead, flathead, washerhead, and so forth. Letters and digits indicate their material composition, length, and thickness. Examples of AN and NAS code numbers follow.

AN501B–416–7
- AN = Air Force–Navy standard.
- 501 = fillister-head, fine thread.
- B = brass.
- 416 = 4/16-inch diameter.
- 7 = 7/16-inch length.

The letter "D" in place of the "B" would indicate that the material is 2017-T aluminum alloy. The letter "C" would designate corrosion-resistant steel. An "A" placed before the material code letter would indicate that the head is drilled for safetying.

NAS144DH–22
- NAS = National Aircraft Standard.
- 144 = head style; diameter and thread—1/4–28 bolt, internal wrenching.
- DH = drilled head.
- 22 = screw length in 16ths of an inch—1 3/8 inches long.

The basic NAS number identifies the part. The suffix letters and dash numbers separate different sizes, plating material, drilling specifications, etc. The dash numbers and suffix letters do not have standard meanings. It is necessary to refer to a specific NAS page in the Standards book for the legend.

REPAIR OF DAMAGED INTERNAL THREADS

Installation or replacement of bolts is simple when compared to the installation or replacement of studs. Bolt heads and nuts are cut in the open, whereas studs are installed into internal threads in a casting or built-up assembly. Damaged threads on bolts or nuts can be seen and only require replacement of the defective part. If internal threads are damaged, two alternatives are apparent: the part may be replaced or the threads repaired or replaced. Correction of the thread problem is usually cheaper and more convenient. Two methods of repairing are by replacement bushings or heli-coils.

Replacement Bushings

Bushings are usually special material (steel or brass spark plug bushings into aluminum cylinder heads). A material that will resist wear is used where removal and replacement is frequent. The external threads on the bushing are usually coarse. The bushing is installed, a thread lock compound may or may not be used, and staked to prevent loosening. Many bushings have left-hand threads external and right-hand threads internal. With this installation, removal of the bolt or stud (right-hand threads) tends to tighten the bushing.

Bushings for common installations such as spark plugs may be up to .040 oversize (in increments of .005). Original installation and overhaul shop replacements are shrunk fit: a heated cylinder head and a frozen bushing.

Heli-coils

Heli-coils are precision formed screw thread coils of 18–8 stainless steel wire having a diamond shaped cross-section (figure 6–14). They form unified coarse or unified fine thread classes 2-band 3B when assembled into (heli-coil) threaded holes. The assembled insert accommodates UNJ (controlled radius root) male threaded members. Each insert has a driving tang with a notch to facilitate removal of the tang after the insert is screwed into a heli-coil tapped hole.

They are used as screw thread bushings. In addition to being used to restore damaged threads, they are used in the original design of missiles, aircraft engines, and all types of mechanical equipment and accessories to protect and strengthen tapped threads in light materials, metals, and plastics, particularly in locations which require frequent assembly and disassembly, and/or where a screw locking action is desired.

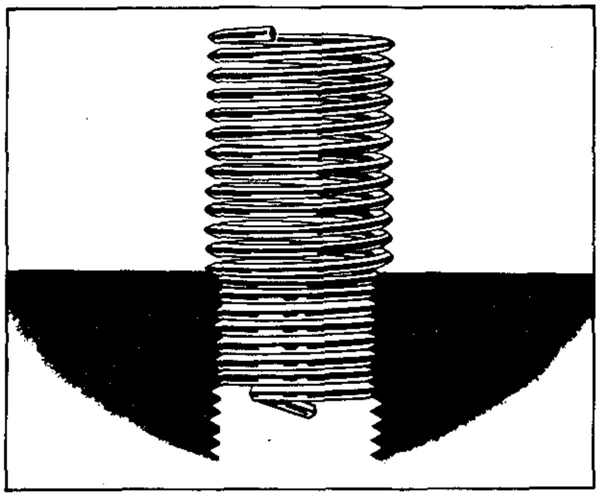


FIGURE 6–14. Heli-coil insert.

Heli-Coil Installation

Heli-coil installation (figure 6–15) is a 5 to 6 step operation, depending upon how the last step is classed. The following steps are for instructional purposes only. The manufacturer's instructions should be followed during installation.

Step 1: Determine what threads are damaged.

Step 2: (a) New installation of heli-coil, drill out damaged threads to minimum depth specified.
(b) Previously installed heli-coil. Using proper size extracting tool, place edge of blade in 90° from the edge of the insert. Tap with hammer to seat tool. Turn to left, applying pressure, until insert backs out. Threads are not damaged if insert is properly removed.

Step 3: Tap. Use the tap of required nominal thread size. The tapping procedure is the same as standard thread tapping. Tap length must be equal to or exceed the requirement.

Step 4: Gage. Threads may be checked with a heli-coil thread gage.

Step 5: Insert Assembly. Using proper tool, install insert to a depth that puts end of top coil $\frac{1}{4}$ to $\frac{1}{2}$ turn below the top surface of the tapped hole.

Step 6: Tang break-off.
Select proper break-off tool. Tangs should be removed from all drilled through holes. In blind holes the tangs may be removed when necessary if enough hole depth is provided below the tang of the installed insert.

These are not to be considered specific instructions on heli-coil installation. The manufacturer's instruction must be followed when making an installation.

Heli-coils are available for the following threads: unified coarse, unified fine, metric, spark plug and national taper pipe threads.

REPAIR OF DAMAGED HOLES WITH ACRES FASTENER SLEEVES

Acres fastener sleeves are thin wall, tubular, elements with a flared end. The sleeves are installed in holes to accept standard bolts and rivet type fasteners. The existing fastener holes are drilled $\frac{1}{64}$-inch oversize for installation of the sleeves. The sleeves are manufactured in one inch increments. Along their length grooves provide a place to break or cut off excess length to match fastener grip range. The grooves also provide a place to hold adhesive or sealing agents when bonding sleeve into the hole.

Advantages and Limitations

The sleeves are used in holes which must be drilled $\frac{1}{64}$-inch oversize to clean up corrosion or other damage. The oversize hole with the sleeve installed allows the use of the original diameter fastener in the repaired hole. The sleeves can be used in areas of high galvanic corrosion where the corrosion must be confined to a readily replaceable part. Oversizing of holes reduces the net cross sectional area of a part and should not be done unless absolutely required.

The manufacturer of the aircraft, aircraft engine or aircraft component should be consulted prior to repair of damaged holes with acres sleeves.

Identification

The sleeve is identified by a standard code number (figure 6–16A) which represents the type and style of sleeve, a material code, the fastener shank diameter, surface finish code letter and grip tang for the sleeve. The type and material of the sleeve is represented by the basic code number. The first dash number represents the diameter of the sleeve for the fastener installed and the second dash represents the grip length of the sleeve. The required length of the sleeve is determined on installation and the excess is broken off of the sleeve. A JK5512A–05N–10 is a 100° low profile head sleeve of aluminum alloy. The diameter is for a $\frac{5}{32}$ inch fastener with no surface finish and is $\frac{5}{8}$ inch in length.

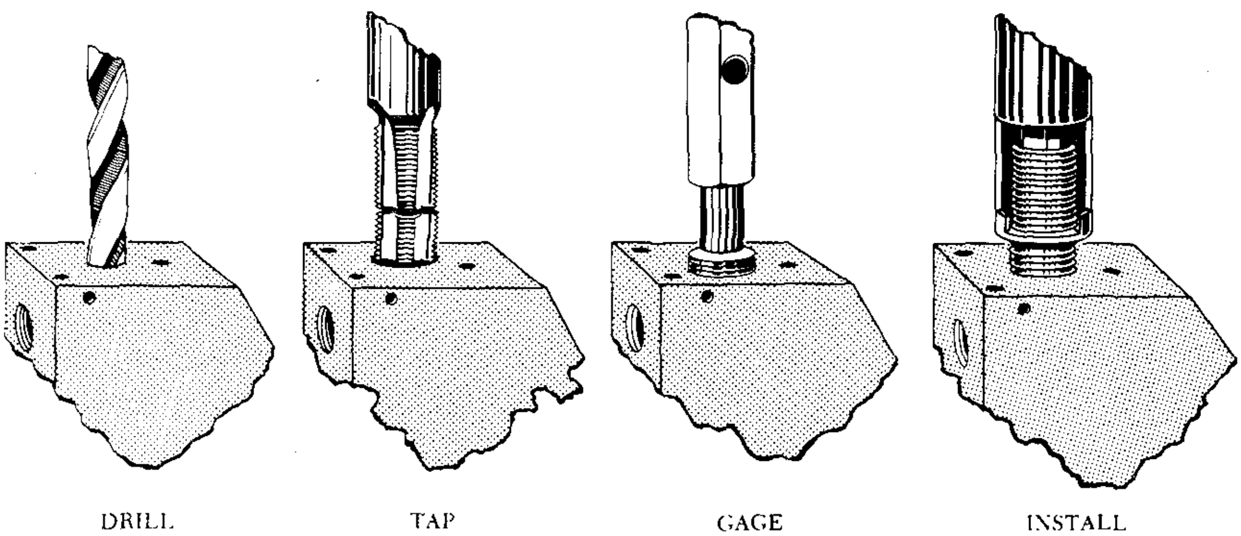
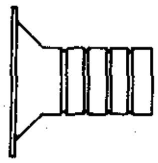
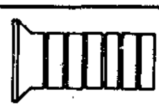
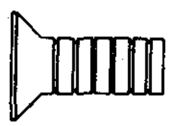
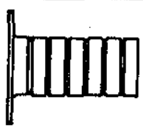
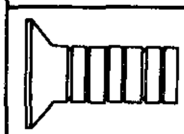


FIGURE 6–15. Heli-coil installation.

ACRES SLEEVE	TYPE	Basic Part Number
	100° 509 Tension Head Plus Flange	JK5610
	Protruding Head (Shear)	JK5511
	100° Low Profile Head	JK5512
	100° Standard Profile Head (509 Type)	JK5516
	Protruding Head (Tension)	JK5517
	100° Oversize Tension Head (1/64 Oversize Bolt)	JK5533

PART NUMBER BREAKDOWN

JK5511 A 04 N 08 L

- L — "L" at end of part number indicates cetyl alchol lubricant
- 08 — Length in sixteenth inch increments. (Required installation length by breaking off at proper groove)
- N — Surface Finish
  - N = No finish
  - C = Chemical film per MIL-C-554)
- 04 — Fastener shank diameter in 32nds.
- A — Material code [1]
- JK5511 — Basic part number

MATERIAL	MATERIAL CODE
5052 Aluminum alloy (1/2 hard)	A
6061 Aluminum alloy (T6 condition)	B
A286 Stainless steel (passivate)	C

SLEEVE PART NO.	BOLT SIZE	[2] SLEEVE LENGTH
JK5511( )04 ( )( ) JK5512( )04 ( )( ) JK5516( )04 ( )( ) JK5517( )04 ( )( )	1/8	8
JK5511( )45 ( )( ) JK5512 JK5516( )45 ( )( ) JK5517( )45 ( )( )	#6	8
JK5511( )05 ( )( ) JK5512( )05 ( )( ) JK5516( )05 ( )( ) JK5517( )05 ( )( )	5/32	10
JK5511( )55 ( )( ) JK5512( )55 ( )( ) JK5516( )55 ( )( ) JK5517( )55 ( )( ) JK5610( )55 ( )( )	#8	10
JK5511( )06 ( )( ) JK5512( )06 ( )( ) JK5516( )06 ( )( ) JK5517( )06 ( )( ) JK5610( )06 ( )( )	#10	12
JK5511( )08 ( )( ) JK5512( )08 ( )( ) JK5516( )08 ( )( ) JK5517( )08 ( )( ) JK5610( )08 ( )( )	1/4	16
JK5511( )10 ( )( ) JK5512( )10 ( )( ) JK5516( )10 ( )( ) JK5517( )10 ( )( ) JK5610( )10 ( )( )	5/16	16
JK5511( )12 ( )( ) JK5512( )12 ( )( ) JK5516( )12 ( )( ) JK5517( )12 ( )( ) JK5610( )12 ( )( )	3/8	16

ACRES SLEEVE FOR 1/64 OVERSIZE BOLT

SLEEVE PART NO. [1]	BOLT SIZE	[2] SLEEVE LENGTH
JK5533( )06 ( )( )	13/64	12
JK5533( )08 ( )( )	17/64	16
JK5533( )10 ( )( )	21/64	16
JK5533( )12 ( )( )	25/24	16

NOTES

[1] Acres sleeve, JK5533 1/64 oversize available in A286 steel only.

[2] Acres sleeve length in sixteenth inch increments.

FIGURE 6–16A. Acres sleeve identification.

HOLE PREPARATION FOR 1/64 OVERSIZE BOLT

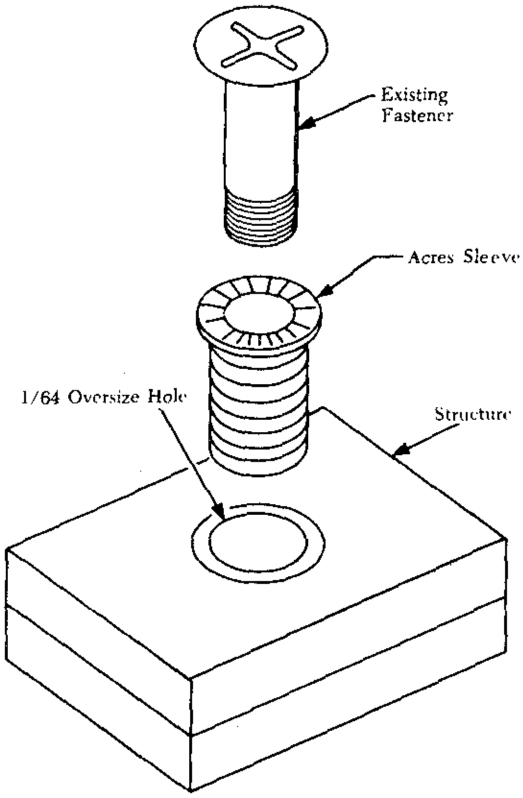
BOLT SIZE	DRILL NO.	DRILL DIA.
13/64	7/32	0.2187
17/64	9/32	0.2812
21/64	11/32	0.3437
25/64	13/32	0.4062

HOLE PREPARATION

	STANDARD FIT		CLOSE FIT	
BOLT SIZE	DRILL NO.	DRILL DIA.	DRILL NO.	DRILL DIA.
1/8	9/64	0.1406	28	0.1405
#6	23	0.1540	24	0.1520
5/32	11/64	0.1719	18	0.1695
#8	15	0.1800	16	0.1770
#10	5	0.2055	6	0.2040
1/4	14	0.2660	17/64	0.2656
5/16	21/64	0.3281		
3/8	25/64	0.3908		

INSTALLATION PROCEDURE

A. DRILL OUT CORROSION OR DAMAGE TO EXISTING HOLE TO 1/64 OVERSIZE.
B. SELECT PROPER TYPE AND LENGTH ACRES SLEEVE FOR EXISTING FASTENER.
C. BOND SLEEVE IN STRUCTURE HOLE WITH MIL-S-8802 CLASS A 1/2 SEALANT.



ACRES SLEEVE INSTALLATION

FIGURE 6–16B. Acres sleeve identification.

Hole Preparation

See figure 6–16 for drill number for standard or close fit holes. Inspect hole after drilling to assure all corrosion is removed before installing the sleeve. The hole must also be the correct shape and free from burrs. The countersink must be enlarged to receive the flare of the sleeve so the sleeve is flush with the surrounding surface.

Installation

After the correct type and diameter sleeve have been selected, use the 6501 sleeve breakoff tool for final installation length. See figure 6–16B for the sleeve breakoff procedure. The sleeve may be installed with or without being bonded in the hole. When bonding the sleeve in a hole, use MIL–S–8802A1/2 sealant. Reinstall original size fastener and torque as required.

Sleeve Removal

Sleeves not bonded in the hole may be removed by either driving them out with a drift pin of the same diameter as the outside diameter of the sleeve or they may be deformed and removed with a pointed tool. Bonded sleeves may be removed by this method, but care should be used not to damage the structure hole. If this method cannot be used, drill the sleeves out with a drill 0.004 to 0.008 smaller than the installation drill size. The remaining portion of the sleeve after drilling can be removed using a pointed tool and applying an adhesive solvent to the sealant.

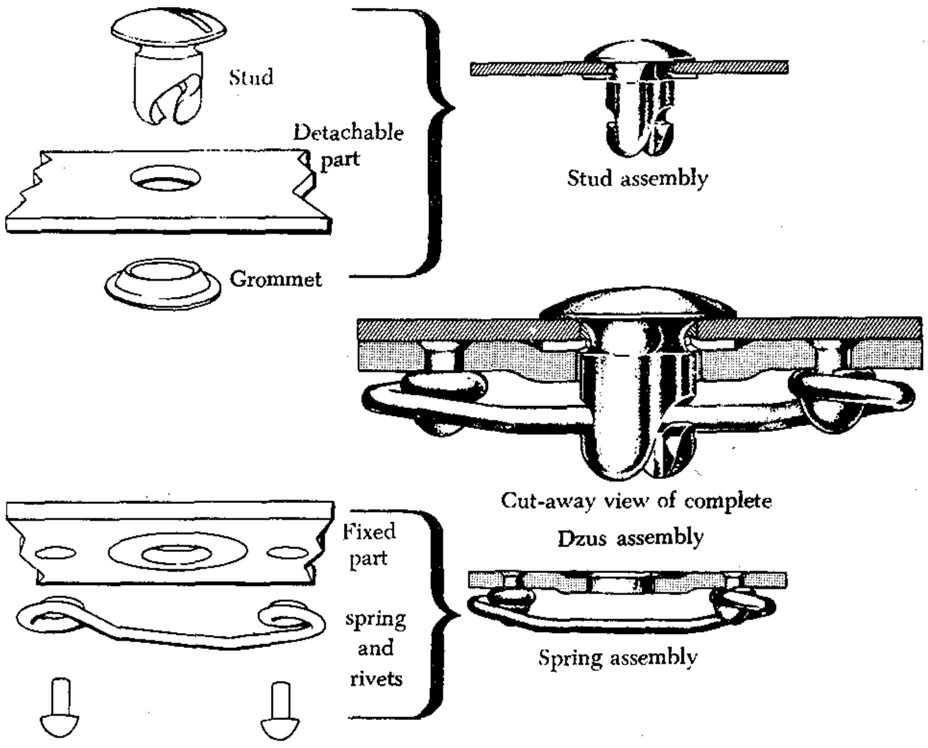


FIGURE 6–17. Dzus fastener.

TURNLOCK FASTENERS

Turnlock fasteners are used to secure inspection plates, doors, and other removable panels on aircraft. Turnlock fasteners are also referred to by such terms as quick-opening, quick-action, and stressed-panel fasteners. The most desirable feature of these fasteners is that they permit quick and easy removal of access panels for inspection and servicing purposes.

Turnlock fasteners are manufactured and supplied by a number of manufacturers under various trade names. Some of the most commonly used are the Dzus, Camloc, and Airloc.

Dzus Fasteners

The Dzus turnlock fastener consists of a stud, grommet, and receptacle. Figure 6–17 illustrates an installed Dzus fastener and the various parts.

The grommet is made of aluminum or aluminum alloy material. It acts as a holding device for the stud. Grommets can be fabricated from 1100 aluminum tubing, if none are available from normal sources.

The spring is made of steel, cadmium plated to prevent corrosion. The spring supplies the force that locks or secures the stud in place when two assemblies are joined.

The studs are fabricated from steel and are cadmium plated. They are available in three head styles; wing, flush, and oval. Body diameter, length, and head type may be identified or determined by the markings found on the head of the stud. (See figure 6–18.) The diameter is always measured in sixteenths of an inch. Stud length is measured in hundredths of an inch and is the distance from the head of the stud to the bottom of the spring hole.

A quarter of a turn of the stud (clockwise) locks the fastener. The fastener may be unlocked only by turning the stud counterclockwise. A

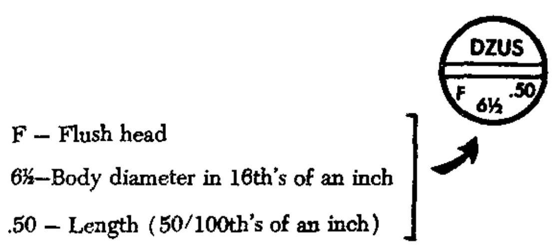


FIGURE 6–18. Dzus identification.

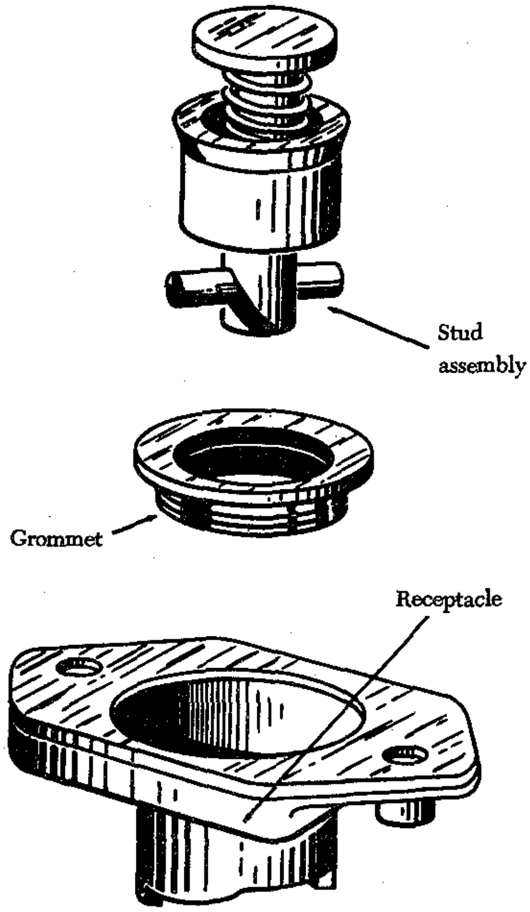


FIGURE 6–19. Camloc fastener.

Dzus key or a specially ground screwdriver locks or unlocks the fastener.

Camloc Fasteners

Camloc fasteners are made in a variety of styles and designs. Included among the most commonly used are the 2600, 2700, 40S51, and 4002 series in the regular line, and the stressed-panel fastener in the heavy-duty line. The latter is used in stressed panels which carry structural loads.

The Camloc fastener is used to secure aircraft cowlings and fairings. It consists of three parts; a stud assembly, a grommet, and a receptacle. Two types of receptacles are available, the rigid type and the floating type. Figure 6–19 illustrates the Camloc fastener.

The stud and grommet are installed in the removable portion; the receptacle is riveted to the structure of the aircraft. The stud and grommet are installed in either a plain, dimpled, countersunk, or counterbored hole, depending upon the location and thickness of the material involved.

A quarter turn (clockwise) of the stud locks the fastener. The fastener can be unlocked only by turning the stud counterclockwise.

Airloc Fasteners

The Airloc fastener shown in figure 6–20 consists of three parts, a stud, a cross pin, and a stud receptacle. The studs are manufactured from steel and case hardened to prevent excessive wear. The stud hole is reamed for a press fit of the cross pin.

The total amount of material thickness to be secured with the Airloc fastener must be known before the correct length of stud can be selected for installation. The total thickness of material that each stud will satisfactorily lock together is stamped on the head of the stud in thousandths of an inch (.040, .070, .190, etc.). Studs are manufactured in three head styles; flush, oval, and wing.

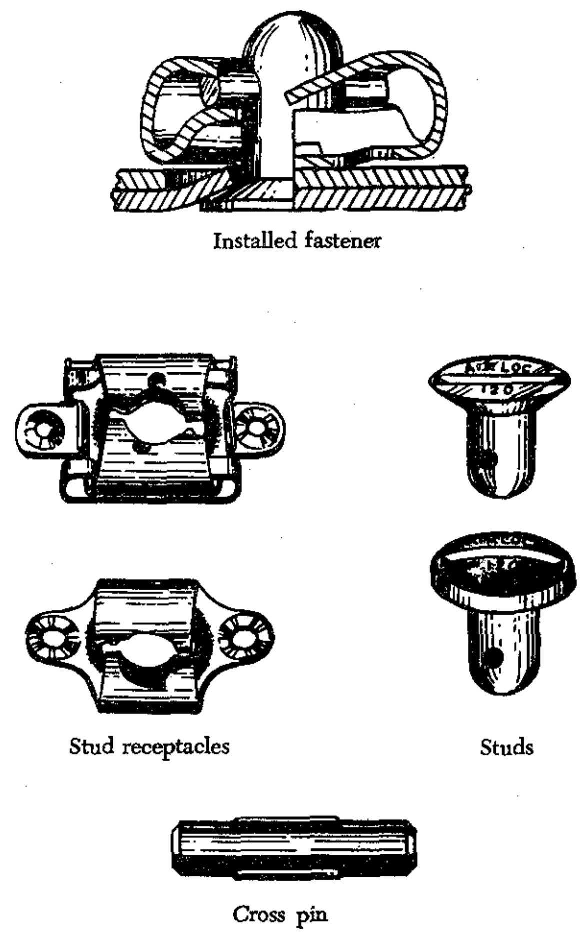


FIGURE 6–20. Airloc fastener.

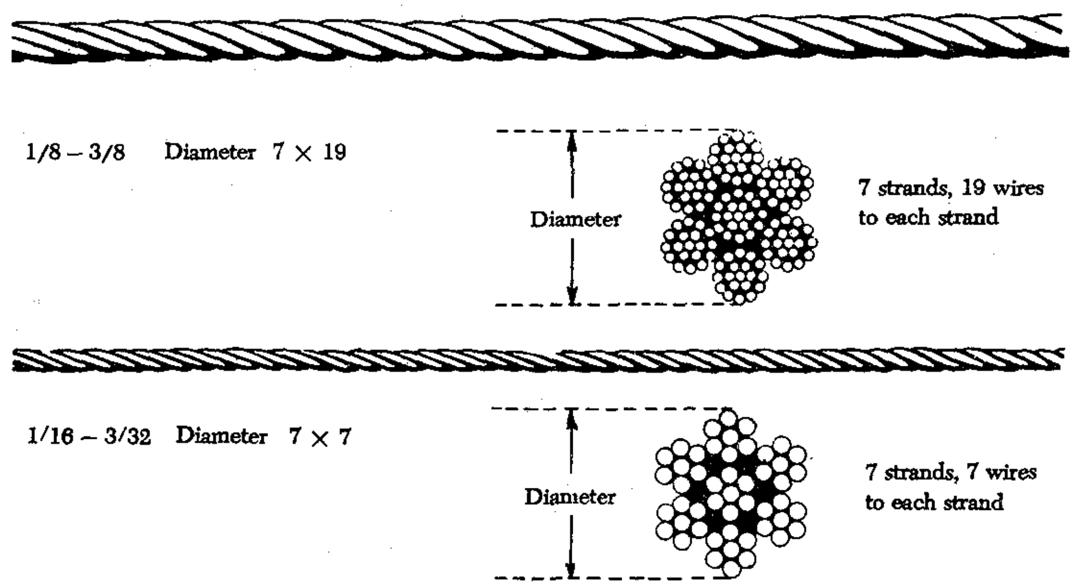


FIGURE 6–21. Cable cross sections.

The cross pin (figure 6–20) is manufactured from chrome-vanadium steel and heat treated to provide maximum strength, wear, and holding power. It should never be used the second time; once removed from the stud, it should be replaced with a new pin.

Receptacles for Airloc fasteners are manufactured in two types, rigid and floating. Sizes are classified by number—No. 2, No. 5, and No. 7. They are also classified by the center-to-center distance between the rivet holes of the receptacle: No. 2, $\frac{3}{4}$ inch; No. 5, 1 inch; and No. 7, $1\frac{3}{8}$ inch. Receptacles are fabricated from high-carbon, heat-treated steel. An upper wing assures ejection of the stud when unlocked and enables the cross pin to be held in a locked position between the upper wing, cam, stop, and wing detent, regardless of the tension to which the receptacle is subjected.

CONTROL CABLES

Cables are the most widely used linkage in primary flight control systems. Cable-type linkage is also used in engine controls, emergency extension systems for the landing gear, and various other systems throughout the aircraft.

Cable-type linkage has several advantages over the other types. It is strong and light in weight, and its flexibility makes it easy to route through the aircraft. An aircraft cable has a high mechanical efficiency and can be set up without backlash, which is very important for precise control.

Cable linkage also has some disadvantages. Tension must be adjusted frequently due to stretching and temperature changes.

Aircraft control cables are fabricated from carbon steel or stainless steel.

Cable Construction

The basic component of a cable is a wire. The diameter of the wire determines the total diameter of the cable. A number of wires are preformed into a helical or spiral shape and then formed into a strand. These preformed strands are laid around a straight center strand to form a cable.

Cable designations are based on the number of strands and the number of wires in each strand. The most common aircraft cables are the 7 × 7 and 7 × 19.

The 7 × 7 cable consists of seven strands of seven wires each. Six of these strands are laid around the center strand (see figure 6–21). This is a cable of medium flexibility and is used for trim tab controls, engine controls, and indicator controls.

The 7 × 19 cable is made up of seven strands of 19 wires each. Six of these strands are laid around the center strand (see figure 6–21). This cable is extra flexible and is used in primary control systems and in other places where operation over pulleys is frequent.

Aircraft control cables vary in diameter, ranging from 1/16 to 3/8 inch. The diameter is measured as shown in figure 6–21.

Cable Fittings

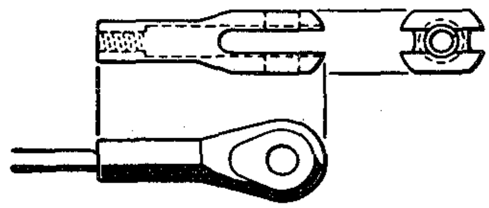
Cables may be equipped with several different types of fittings such as terminals, thimbles, bushings, and shackles.

Terminal fittings are generally of the swaged type. They are available in the threaded end, fork end, eye end, single-shank ball end, and double-shank ball end. The threaded end, fork end, and eye end terminals are used to connect the cable to a turnbuckle, bellcrank, or other linkage in the system. The ball-end terminals are used for attaching cables to quadrants and special connections where space is limited. Figure 6–22 illustrates the various types of terminal fittings.

The 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.

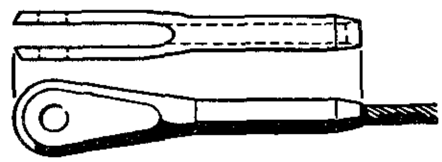
AN663 Double shank ball end terminal

AN664 Single shank ball end terminal

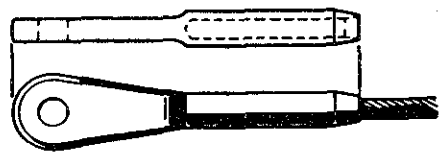


AN665 Rod end terminal

AN666 Threaded cable terminal



AN667 Fork end cable terminal



AN668 Eye end cable terminal

FIGURE 6–22. Types of terminal fittings.

Turnbuckles

A turnbuckle assembly is a mechanical screw device consisting of two threaded terminals and a threaded barrel. Figure 6–23 illustrates a typical turnbuckle assembly.

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

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

After a turnbuckle is properly adjusted, it must be safetied. The methods of safetying turnbuckles are discussed later in this chapter.

PUSH-PULL TUBE LINKAGE

Push-pull tubes are used as linkage in various types of mechanically operated systems. This type linkage eliminates the problem of varying tension and permits the transfer of either compression or tension stress through a single tube.

A push-pull tube assembly consists of a hollow aluminum alloy or steel tube with an adjustable end fitting and a checknut at either end. (See figure 6–24.) The checknuts secure the end fittings after the tube assembly has been adjusted to its correct length. Push-pull tubes are generally made in short lengths to prevent vibration and bending under compression loads.

PINS

The three main types of pins used in aircraft structures are the taper pin, flathead pin, and cotter pin. Pins are used in shear applications and

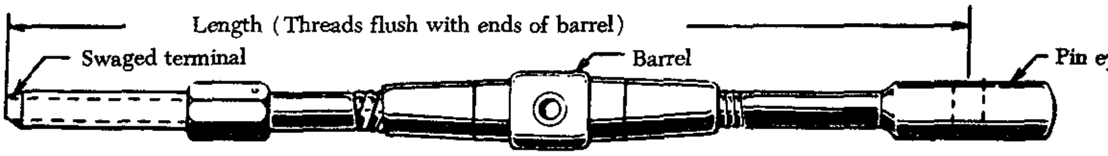


FIGURE 6–23. Typical turnbuckle assembly.

for safetying. Roll pins are finding increasing uses in aircraft construction.

Taper Pins

Plain and threaded taper pins (AN385 and AN386) are used in joints which carry shear loads and where absence of play is essential. The plain taper pin is drilled and usually safetied with wire. The threaded taper pin is used with a taper-pin washer (AN975) and shear nut (safetied with cotter pin) or self-locking nut.

Flathead Pin

Commonly called a clevis pin, the flathead pin (MS20392) is used with tie-rod terminals and in secondary controls which are not subject to continuous operation. The pin is customarily installed with the head up so that if the cotter pin fails or works out, the pin will remain in place.

Cotter Pins

The AN380 cadmium-plated, low-carbon steel cotter pin is used for safetying bolts, screws, nuts, other pins, and in various applications where such safetying is necessary. The AN381 corrosion-resistant steel cotter pin is used in locations where nonmagnetic material is required, or in locations where resistance to corrosion is desired.

Rollpins

The rollpin is a pressed-fit pin with chamfered ends. It is tubular in shape and is slotted the full length of the tube. The pin is inserted with hand tools and is compressed as it is driven into place. Pressure exerted by the roll pin against the hole walls keeps it in place, until deliberately removed with a drift punch or pin punch.

SAFETY METHODS

Safetying is the process of securing all aircraft, bolts, nuts, screws, pins, and other fasteners so that they do not work loose due to vibration. A familiarity with the various methods and means of safetying equipment on an aircraft is necessary in order to perform maintenance and inspection.

There are various methods of safetying aircraft parts. The most widely used methods are safety wire, cotter pins, lockwashers, snap-rings, and special nuts, such as self-locking nuts, pal nuts, and jamnuts. Some of these nuts and washers have been previously described in this chapter.

Safety Wiring

Safety wiring is the most positive and satisfactory method of safetying capscrews, studs, nuts, boltheads, and turnbuckle barrels which cannot be safetied by any other practical means. It is a method of wiring together two or more units in

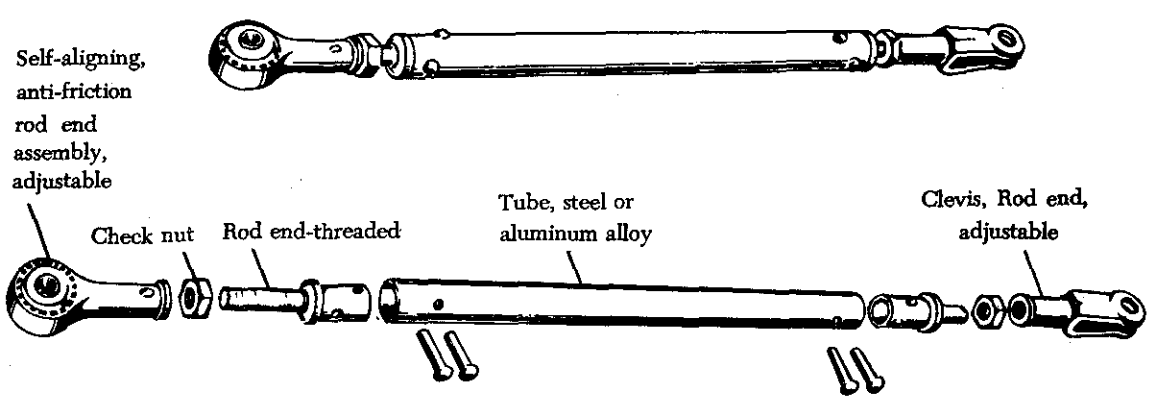


FIGURE 6–24. Push-pull tube assembly.

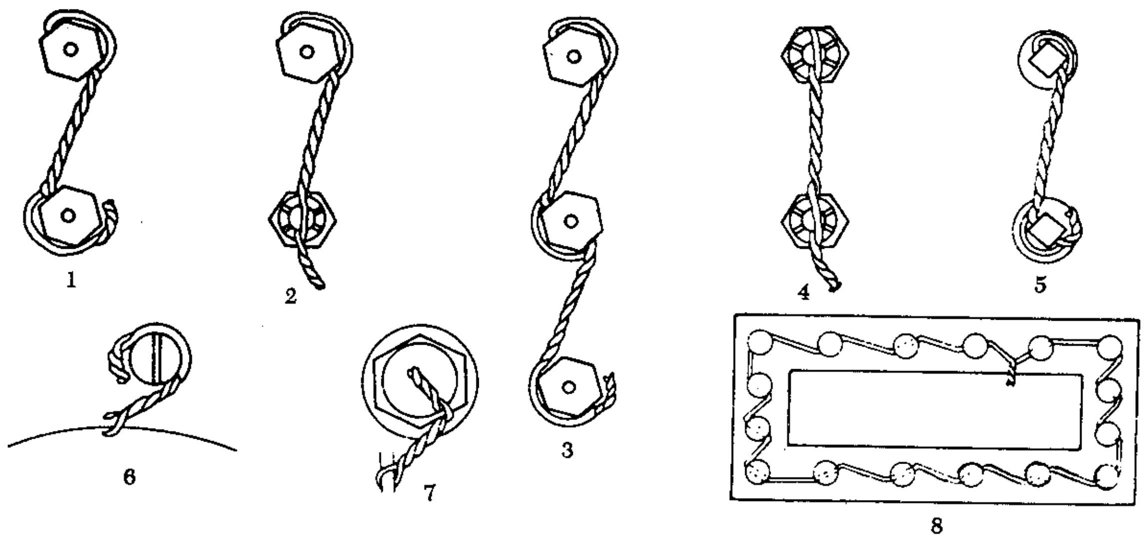


FIGURE 6–25. Safety wiring methods.

such a manner that any tendency of one to loosen is counteracted by the tightening of the wire.

Nuts, Bolts, and Screws

Nuts, bolts, and screws are safety wired by the single-wire or double-twist method. The double-twist method is the most common method of safety wiring. The single-wire method may be used on small screws in a closely spaced closed geometrical pattern, on parts in electrical systems, and in places that are extremely difficult to reach.

Figure 6–25 is an illustration of various methods which are commonly used in safety wiring nuts, bolts, and screws. Careful study of figure 6–25 shows that:

a. Examples 1, 2, and 5 illustrate the proper method of safety wiring bolts, screws, square-head plugs, and similar parts when wired in pairs.

b. Example 3 illustrates several components wired in series.

c. Example 4 illustrates the proper method of wiring castellated nuts and studs. (Note that there is no loop around the nut.)

d. Examples 6 and 7 illustrate a single-threaded component wired to a housing or lug.

e. Example 8 illustrates several components in a closely spaced closed geometrical pattern, using a single-wire method.

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 is dependent on the application. For instance, when safety-wiring widely spaced bolts by the double-twist method, a group of three should be the maximum number in a series.

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

Parts being safety-wired should be torqued to recommend values and the holes aligned before attempting the safetying operation. Never over torque or loosen a torqued nut to align safety wire holes.

Oil Caps, Drain Cocks, and Valves

These units are safety wired as shown in figure 6–26. In the case of the oil cap, the wire is anchored to an adjacent fillister head screw.

This system applies to any other unit which must be safety wired individually. Ordinarily, anchorage lips are conveniently located near these individual parts. When such provision is not made, the safety wire is fastened to some adjacent part of the assembly.

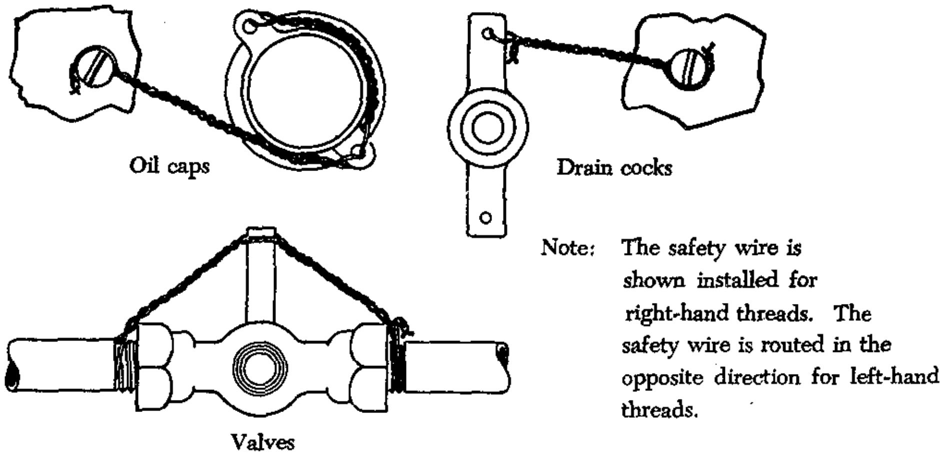


FIGURE 6–26. Safety wiring oil caps, drain cocks, and valves.

Electrical Connectors

Under conditions of severe vibration, the coupling nut of a connector may vibrate loose, and with sufficient vibration the connector may come apart. When this occurs, the circuit carried by the cable opens. The proper protective measure to prevent this occurrence is by safety wiring as shown in figure 6–27. The safety wire should be as short as practicable and must be installed in such a manner that the pull on the wire is in the direction which tightens the nut on the plug.

Turnbuckles

After a turnbuckle has been properly adjusted, it must be safetied. There are several methods of safetying turnbuckles; however, only two methods will be discussed in this section. These methods are illustrated in figure 6–28 (A) and 6–28 (B). The clip-locking method is used only on the most modern aircraft. The older type aircraft still use the type turnbuckles that require the wire-wrapping method.

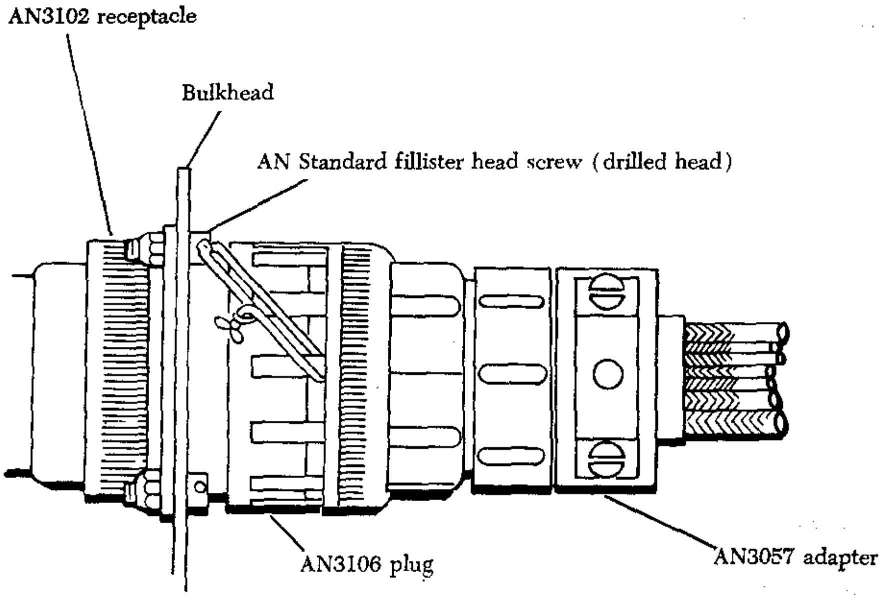


FIGURE 6–27. Safety wiring attachment for plug connectors.

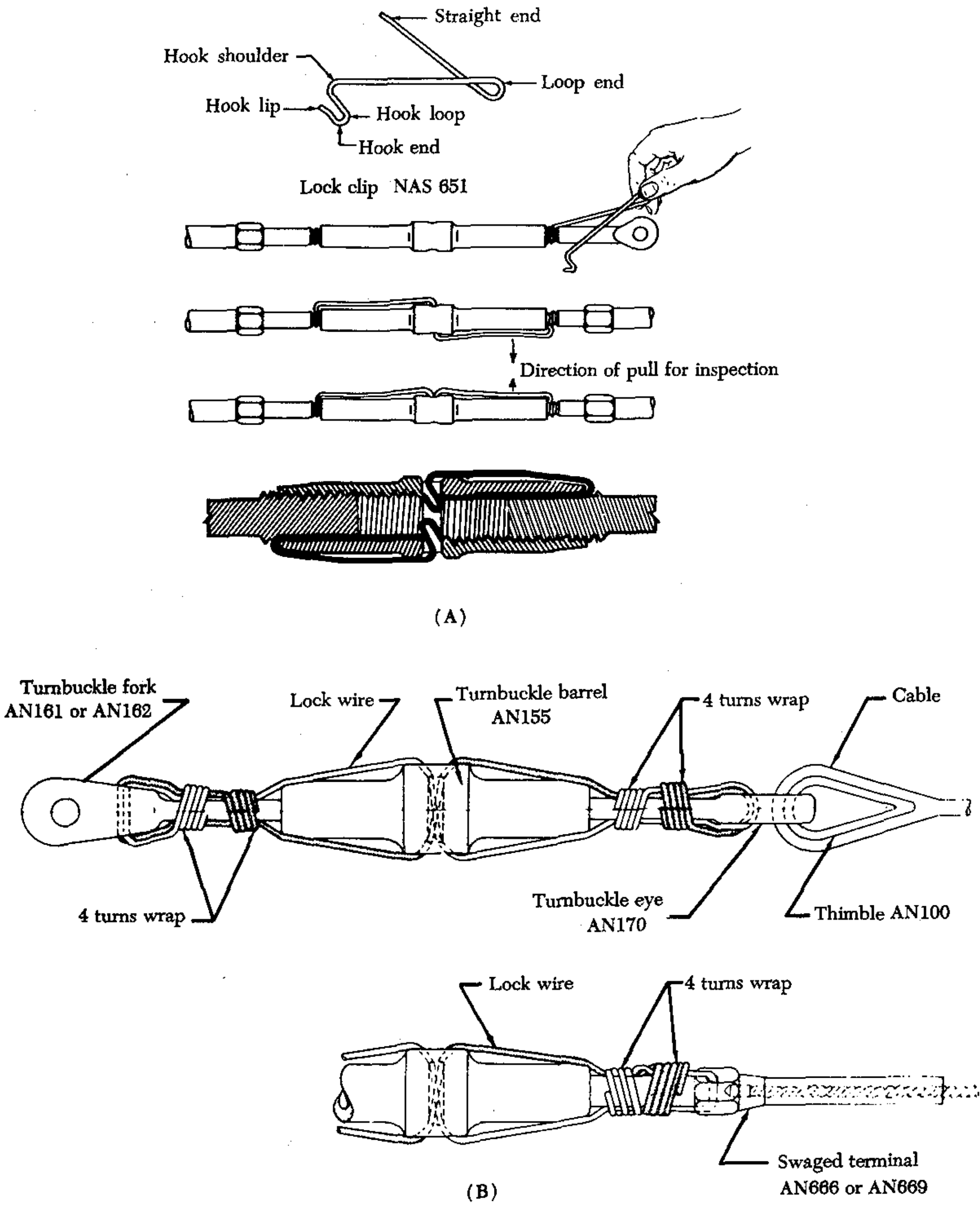


FIGURE 6–28. Safetying turnbuckles;
(A) Clip-locking method; (B) wire-wrapping method.

Double-wrap Method

Of the methods using safety wire for safetying turnbuckles, the double-wrap method is preferred, although the single-wrap methods described are satisfactory. The method of double-wrap safetying is shown in figure 6–28 (B). Use two separate lengths of the proper wire as shown in figure 6–29.

Cable size (in.)	Type of wrap	Diameter of safety wire (in.)	Material (annealed condition)
1/16	Single	.020	Stainless steel
3/32	Single	.040	Copper, brass[1]
1/8	Single	.040	Stainless steel
1/8	Double	.040	Copper, brass[1]
1/8	Single	.057 min	Copper, brass[1]
5/32 and greater	Single	.057	Stainless steel

1. Galvanized or tinned steel, or soft iron wires are also acceptable.

FIGURE 6–29. Turnbuckle safetying guide.

Run one end of the wire through the hole in the barrel of the turnbuckle and bend the ends of the wire towards opposite ends of the turnbuckle. Then pass the second length of the wire into the hole in the barrel and bend the ends along the barrel on the side opposite the first. Then pass the wires at the end of the turnbuckle in opposite directions through the holes in the turnbuckle eyes or between the jaws of the turnbuckle fork, as applicable. Bend the laid wires in place before cutting off the wrapped wire. Wrap the remaining length of safety wire at least four turns around the shank and cut it off. Repeat the procedure at the opposite end of the turnbuckle.

When a swaged terminal is being safetied, pass the ends of both wires, if possible, through the hole provided in the terminal for this purpose and wrap both ends around the shank as described above.

If the hole is not large enough to allow passage of both wires, pass the wire through the hole and loop it over the free end of the other wire, and then wrap both ends around the shank as described.

Single-wrap Method

The single-wrap safetying methods described in the following paragraphs are acceptable but are not the equal of the double-wrap methods.

Pass a single length of wire through the cable eye or fork, or through the hole in the swaged terminal at either end of the turnbuckle assembly. Spiral each of the wire ends in opposite directions around the first half of the turnbuckle barrel so that the wires cross each other twice. Thread both wire ends through the hole in the middle of the barrel so that the third crossing of the wire ends is in the hole. Again, spiral the two wire ends in opposite directions around the remaining half of the turnbuckle, crossing them twice. Then, pass one wire end through the cable eye or fork, or through the hole in the swaged terminal. In the manner described above, wrap both wire ends around the shank for at least four turns each, cutting off the excess wire.

An alternate to the above method is to pass one length of wire through the center hole of the turnbuckle and bend the wire ends toward opposite ends of the turnbuckle. Then pass each wire end through the cable eye or fork, or through the hole in the swaged terminal and wrap each wire end around the shank for at least four turns, cutting off the excess wire. After safetying, no more than three threads of the turnbuckle threaded terminal should be exposed.

General Safety Wiring Rules

When using the safety wire method of safetying, the following general rules should be followed:

1. 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.
2. The safety wire must be new upon each application.
3. When castellated nuts are to be secured with safety wire, tighten the nut to the low side of the selected torque range, unless otherwise specified, and if necessary, continue tightening until a slot aligns with the hole.

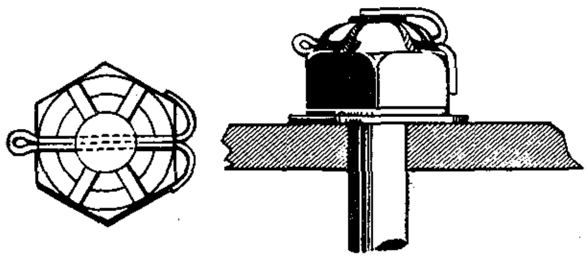


FIGURE 6–30. Cotter pin installations.

4. All safety wires must be tight after installation, but not under such tension that normal handling or vibration will break the wire.
5. The wire must be applied so that all pull exerted by the wire tends to tighten the nut.
6. Twists should be tight and even, and the wire between the nuts as taut as possible without overtwisting.
7. The safety wire should always be installed and twisted so that the loop around the head stays down and does not tend to come up over the bolthead, causing a slack loop.

Cotter Pin Safetying

Cotter pin installation is shown in figure 6–30. Castellated nuts are used with bolts that have been drilled for cotter pins. The cotter pin should fit neatly into the hole, with very little sideplay. The following general rules apply to cotter pin safetying:

1. The prong bent over the bolt end should not extend beyond the bolt diameter. (Cut it off if necessary.)
2. The prong bent down should not rest against the surface of the washer. (Again, cut it off if necessary.)
3. If the optional wraparound method is used, the prongs should not extend outward from the sides of the nut.
4. All prongs should be bent over a reasonable radius. Sharp-angled bends invite breakage. Tapping lightly with a mallet is the best method of bending the prongs.

Snaprings

A snapring is a ring of metal, either round or flat in cross section, which is tempered to have springlike action. This springlike action will hold the snapring 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. A special type of pliers is designed to install each type of snapring.

Snaprings can be reused as long as they retain their shape and springlike action.

External-type snaprings may be safety wired, but internal types are never safetied. Safety wiring of an external type snapring is shown in figure 6–31.

RIVETS

An aircraft, even though made of the best materials and strongest parts, would be of doubtful value unless those parts were firmly held together.

Several methods are used to hold metal parts together; they include riveting, bolting, brazing, and welding. The process used must produce a union that will be as strong as the parts that are joined.

Aluminum and its alloys are difficult to solder. To make a good union and a strong joint, aluminum parts can be welded, bolted, or riveted together. Riveting is satisfactory from the standpoint of strength and neatness, and is much easier to do than welding. It is the most common method used to fasten or join aluminum alloys in aircraft construction and repair.

A rivet is a metal pin used to hold two or more metal sheets, plates, or pieces of material together. A head is formed on one end when the rivet is manufactured. The shank of the rivet is placed through matched holes in two pieces of material, and the tip is then upset to form a second head to clamp the two pieces securely together. The second head, formed either by hand or by pneumatic equipment, is called a "shop head." The shop head functions in the

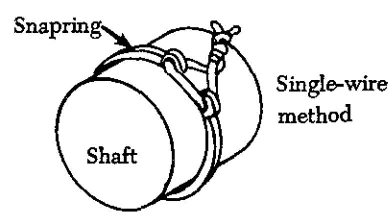


FIGURE 6–31. External type snap ring with safety wire installed.

same manner as a nut on a bolt. In addition to their use for joining aircraft skin sections, 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 innumerable bracing members and other parts together.

Two of the major types of rivets used in the aircraft are the common solid-shank type, which must be driven using a bucking bar, and the special (blind) rivets, which may be installed where it is impossible to use a bucking bar.

Solid-Shank Rivets

Solid-shank rivets are generally used in repair work. They are identified by the kind of material of which they are made, their head type, size of shank, and their temper condition. The designation of the solid-shank rivet head type, such as universal head, roundhead, flathead, countersunk head, and brazier head, depends on the cross sectional shape of the head (see figure 6–33). The temper designation and strength are indicated by special markings on the head of the rivet.

The material used for the majority of aircraft solid-shank rivets is aluminum alloy. The strength and temper conditions of aluminum alloy rivets are identified by digits and letters similar to those adopted for the identification of strength and temper conditions of aluminum and aluminum alloy sheet stock. The 1100, 2017-T, 2024-T, 2117-T, and 5056 rivets are the five grades usually available.

The 1100 rivet, which is composed of 99.45 percent pure aluminum, is very soft. It is for riveting the softer aluminum alloys, such as 1100, 3003, and 5052, which are used for nonstructural parts (all parts where strength is not a factor). The riveting of map cases is a good example of where a rivet of 1100 aluminum alloy may be used.

The 2117-T rivet, known as the field rivet, is used more than any other for riveting aluminum alloy structures. The field rivet is in wide demand because it is ready for use as received and needs no further heat-treating or annealing. It also has a high resistance to corrosion.

The 2017-T and 2024-T rivets are used in aluminum alloy structures where more strength is needed than is obtainable with the same size 2217-T rivet. These rivets are annealed and must be kept refrigerated until they are to be driven. The 2017-T rivet should be driven within approximately 1 hour and the 2024-T rivet within 10 to 20 minutes after removal from refrigeration.

The 5056 rivet is used for riveting magnesium alloy structures because of its corrosion-resistant qualities in combination with magnesium.

Mild steel rivets are used for riveting steel parts. The corrosion-resistant steel rivets are for riveting corrosion-resistant steels in firewalls, exhaust stack brackets, and similar structures.

Monel rivets are used for riveting nickel-steel alloys. They can be substituted for those made of corrosion-resistant steel in some cases.

The use of copper rivets in aircraft repair is limited. Copper rivets can be used only on copper alloys or nonmetallic materials such as leather.

Metal temper is an important factor in the riveting process, especially with aluminum alloy rivets. Aluminum alloy rivets have the same heat-treating characteristics as aluminum alloy sheet stock. They can be hardened and annealed in the same manner as sheet aluminum. The rivet must be soft, or comparatively soft, before a good head can be formed. The 2017-T and 2024-T rivets are annealed before being driven. They harden with age.

The process of heat treating (annealing) rivets is much the same as that for sheet stock. Either an electric air furnace, a salt bath, or a hot oil bath is needed. The heat treating range, depending on the alloy, is 625° F. to 950° F. For convenient handling, rivets are heated in a tray or a wire basket. They are quenched in cold water (70° F.) immediately after heat treating.

The 2017-T and 2024-T rivets, which are heat-treatable rivets, begin to age-harden within a few minutes after being exposed to room temperature. Therefore, they must be used immediately after quenching or else be placed in cold storage. The most commonly used means for holding heat-treatable rivets at low temperature (below 32° F.) is to keep them in an electric refrigerator. They are referred to as "icebox" rivets. Under this storage condition, they will remain soft enough for driving for periods up to 2 weeks. Any rivets not used within that time should be removed for re-heat treating.

Icebox rivets attain about one-half their maximum strength in approximately 1 hour after driving and full strength in about 4 days. When 2017-T rivets are exposed to room temperature for 1 hour or longer, they must be subject to re-heat treatment. This also applies to 2024-T rivets exposed to room temperature for a period exceeding 10 minutes.

Once an icebox rivet has been taken from the refrigerator, it should not be mixed with the rivets still in cold storage. If more rivets are removed from the icebox than can be used in 15 minutes, they should be placed in a separate container and stored for re-heat treatment. Heat treatment of rivets may be repeated a number of times if done properly. Proper heating times and temperatures are:

Heating time—air furnace

Rivet alloy	Time at temperature	Heat treating temperature
2024	1 hour	910° F.—930° F.
2017	1 hour	925° F.—950° F.

Heating time–salt bath

Rivet alloy	Time at temperature	Heat treating temperature
2024	30 minutes	910° F.—930° F.
2017	30 minutes	925° F.—950° F.

Most metals, and therefore aircraft rivet stock, are subject to corrosion. Corrosion may be the result of local climatic conditions or the fabrication process used. It is reduced to a minimum by using metals which are highly resistant to corrosion and possess the correct strength-to-weight ratio.

Ferrous metals placed in contact with moist salt air will rust if not properly protected. Nonferrous metals, those without an iron base, do not rust, but a similar process known as corrosion takes place. The salt in moist air (found in the coastal areas) attacks the aluminum alloys. It is a common experience to inspect the rivets of an aircraft which has been operated near salt water and find them badly corroded.

If a copper rivet is inserted into an aluminum alloy structure, two dissimilar metals are brought in contact with each other. Remember, all metals possess a small electrical potential. Dissimilar metals in contact with each other in the presence of moisture cause an electrical current to flow between them and chemical by-products to be formed. Principally, this results in the deterioration of one of the metals.

Group A	Group B
1100	2117
3003	2017
5052	2124
6053	7075

FIGURE 6–32. Aluminum groupings.

Certain aluminum alloys react to each other and, therefore, must be thought of as dissimilar metals. The commonly used aluminum alloys may be divided into the two groups shown in figure 6–32.

Members within either group A or group B can be considered as similar to each other and will not react to others within the same group. A corroding action will take place, however, if any metal of group A comes in contact with a metal in group B in the presence of moisture.

Avoid the use of dissimilar metals whenever possible. Their incompatibility is a factor which was considered when the AN Standards were adopted. To comply with AN Standards, the manufacturers must put a protective surface coating on the rivets. This may be zinc chromate, metal spray, or an anodized finish.

The protective coating on a rivet is identified by its color. A rivet coated with zinc chromate is yellow, an anodized surface is pearl gray, and the metal-sprayed rivet is identified by a silvery-gray color. If a situation arises in which a protective coating must be applied on the job, paint the rivet with zinc chromate before it is used and again after it is driven.

Identification

Markings on the heads of rivets are used to classify their characteristics. These markings may be either a raised teat, two raised teats, a dimple, a pair of raised dashes, a raised cross, a single triangle, or a raised dash; some other heads have no markings. The different markings indicate the composition of the rivet stock. As explained previously, the rivets have different colors to identify the protective surface coating used by the manufacturers.

Roundhead rivets are used in the interior of the aircraft, except where clearance is required for adjacent members. The roundhead rivet has a deep, rounded top surface. The head is large enough to strengthen the sheet around the hole and, at the same time, offer resistance to tension.

The flathead rivet, like the roundhead rivet, is used on interior structures. It is used where maximum strength is needed and where there isn't sufficient clearance to use a roundhead rivet. It is seldom, if ever, used on external surfaces.

The brazier head rivet has a head of large diameter, which makes it particularly adaptable for riveting thin sheet stock (skin). The brazier head rivet offers only slight resistance to the airflow, and because of this factor, it is frequently used for riveting skin on exterior surfaces, especially on aft sections of the fuselage and empennage. It is used for riveting thin sheets exposed to the slipstream. A modified brazier head rivet is also manufactured; it is simply a brazier head of reduced diameter.

The universal head rivet is a combination of the roundhead, flathead, and brazier head. It is used in aircraft construction and repair in both interior and exterior locations. When replacement is necessary for protruding head rivets—roundhead, flathead, or brazier head—they can be replaced by universal head rivets.

The countersunk head rivet is flat topped and beveled toward the shank so that it fits into a countersunk or dimpled hole and is flush with the material's surface. The angle at which the head slopes may vary from 78° to 120°. The 100° rivet is the most commonly used type. These rivets are used to fasten sheets over which other sheets must fit. They are also used on exterior surfaces of the aircraft because they offer only slight resistance to the slipstream and help to minimize turbulent airflow.

The markings on the heads of rivets, indicate the material of which they are made and, therefore, their strength. Figure 6-33 identifies the rivet head markings and the materials indicated by them. Although there are three materials indicated by a plain head, it is possible to distinguish their difference by color. The 1100 is aluminum color; the mild steel is a typical steel color; and the copper rivet is a copper color. Any head marking can appear on any head style of the same material.

Each type of rivet is identified by a part number so that the user can select the correct rivet for the job. The type of rivet head is identified by AN or MS standard numbers. The numbers selected are in series and each series represents a particular type of head. (See figure 6-33.) The most common numbers and the types of heads they represent are:

AN426 or MS20426—countersunk head rivets (100°).
AN430 or MS20430—roundhead rivets.
AN441—flathead rivets.
AN456—brazier head rivets.
AN470 or MS20470—universal head rivets.

There are also letters and numbers added to a part number. The letters designate alloy content; the numbers, rivet diameter and length. The letters in common use for alloy designation are:

A—Aluminum alloy, 1100 or 3003 composition.
AD—Aluminum alloy, 2117-T composition.
D—Aluminum alloy, 2017-T composition.
DD—Aluminum alloy, 2024-T composition.
B—Aluminum alloy, 5056 composition.
C—Copper.
M—Monel.

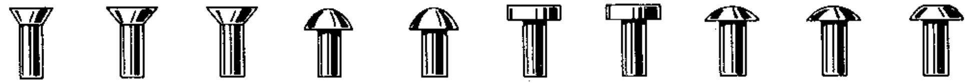
The absence of a letter following the AN standard number indicates a rivet manufactured from mild steel.

The first number following the material composition letters expresses the diameter of the rivet shank in 32nds of an inch. Examples: 3, $\frac{3}{32}$nds; 5, $\frac{5}{32}$nds; etc. (See figure 6-34).

The last number(s), separated by a dash from the preceding number, expresses the length of the rivet shank in 16ths of an inch. Examples: 3, $\frac{3}{16}$ths; 7, $\frac{7}{16}$ths; 11, $\frac{11}{16}$ths; etc. (See figure 6-34.)

An example of identification marking of a rivet is:

AN470AD3-5—complete part number.
AN—Air Force-Navy standard number.
470—universal head rivet.
AD—2117-T aluminum alloy.
3—$\frac{3}{32}$nds in diameter.
5—$\frac{5}{16}$ths in length.



Material	Head Marking	AN Material Code	AN425 78° Counter-Sunk Head	AN426 100° Counter-Sunk Head MS20426*	AN427 100° Counter-Sunk Head MS20427*	AN430 Round Head MS20470*	AN435 Round Head MS20613* MS20615*	AN441 Flat Head	AN442 Flat Head MS20470*	AN455 Brazier Head MS20470*	AN456 Brazier Head MS20470*	AN470 Universal Head MS20470*	* Heat Treat Before Using	Shear Strength P.S.I.	Bearing Strength P.S.I.
1100	Plain	A	X	X		X			X	X	X	X	No	10000	25000
2117T	Recessed Dot	AD	X	X		X			X	X	X	X	No	30000	100000
2017T	Raised Dot	D	X	X		X			X	X	X	X	Yes	34000	113000
2017T-HD	Raised Dot	D	X	X		X			X	X	X	X	No	38000	126000
2024T	Raised Double Dash	DD	X	X		X			X	X	X	X	Yes	41000	136000
5056T	Raised Cross	B		X		X			X	X	X	X	No	27000	90000
7075-T73	Three Raised Dashes		X	X		X			X	X	X	X	No		
Carbon Steel	Recessed Triangle				X		X MS20613*	X					No	35000	90000
Corrosion Resistant Steel	Recessed Dash	F			X		X MS20613*						No	65000	90000
Copper	Plain	C			X		X	X					No	23000	
Monel	Plain	M			X			X					No	49000	
Monel (Nickel-Copper Alloy)	Recessed Double Dots	C					X MS20615*						No	49000	
Brass	Plain						X MS20615*						No		
Titanium	Recessed Large and Small Dot			MS 20426				X					No	95000	

* New specifications are for Design purposes

FIGURE 6–33. Rivet identification chart.

Special (Blind) Rivets

There are many places on an aircraft where access to both sides of a riveted structure or structural part is impossible, or where limited space will not permit the use of a bucking bar. Also, in the attachment of many nonstructural parts such as aircraft interior furnishings, flooring, deicing boots, and the like, the full strength of solid shank rivets is not necessary.

For use in such places, special rivets have been designed which can be bucked from the front. They are sometimes lighter than solid-shank rivets, yet amply strong for their intended use. These rivets are produced by several manufacturers and have unique characteristics that require special installation tools, special installation procedures, and special removal procedures. That is why they are called special rivets. Because these rivets are often inserted in locations where one head (usually the shop head) cannot be seen, they are also called blind rivets.

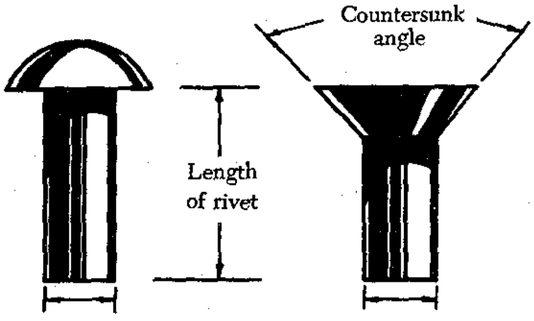


FIGURE 6–34. Methods of measuring rivets.

Mechanically Expanded Rivets

Two classes of mechanically expanded rivets will be discussed here:

(1) Non-structural
 (a) Self-plugging (friction lock) rivets
 (b) Pull-thru rivets
(2) Mechanical lock, flush fracturing, self-plugging rivets.

Self-Plugging

The self-plugging (friction lock) blind rivets are manufactured by several companies: the same general basic information about their fabrication, composition, uses, selection, installation, inspection, and removal procedures apply to all of them.

Self-plugging (friction lock) rivets are fabricated in two parts: A rivet head with a hollow shank or sleeve, and a stem that extends through the hollow

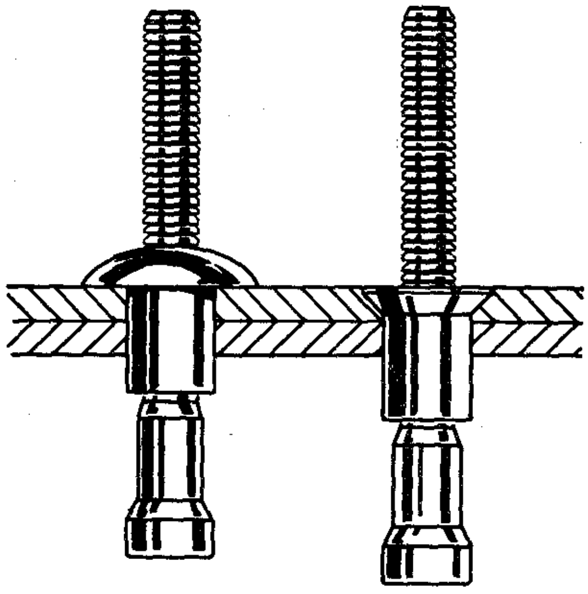


FIGURE 6–35. Self-plugging (friction lock) rivets.

shank. Figure 6–35 illustrates a protruding head and a countersunk head self-plugging rivet produced by one manufacturer.

Several events, in their proper sequence, occur when a pulling force is applied to the stem of the rivet: (1) The stem is pulled into the rivet shank; (2) the mandrel portion of the stem forces the rivet shank to expand; and (3) when friction (or pulling action pressure) becomes great enough it will cause the stem to snap at a breakoff groove on the stem. The plug portion (bottom end of the stem) is retained in the shank of the rivet giving the rivet much greater shear strength than could be obtained from a hollow rivet.

Self-plugging (friction lock) rivets are fabricated in two common head styles: (1) A protruding head similar to the MS20470 or universal head, and (2) a 100° countersunk head. Other head styles are available from some manufacturers.

The stem of the self-plugging (friction lock) rivet may have a knot or knob on the upper portion, or it may have a serrated portion as shown in figure 6–35.

Self-plugging (friction lock) rivets are fabricated from several materials. Rivets are available in the following material combinations: stem 2017 aluminum alloy and sleeve 2117 aluminum alloy; stem 2017 aluminum alloy and sleeve 5056 aluminum alloy; and stem steel and sleeve steel.

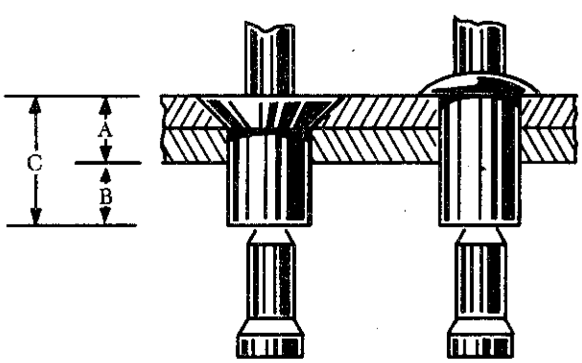
Self-plugging (friction lock) rivets are designed so that installation requires only one person; it is not necessary to have the work accessible from both sides. The pulling strength of the rivet stem is such that a uniform job can always be assured. Because it is not necessary to have access to the opposite side of the work, self-plugging (friction lock) rivets can be used to attach assemblies to hollow tubes, corrugated sheet, hollow boxes, etc. Because a hammering force is not necessary to install the rivet, it can be used to attach assemblies to plywood or plastics.

Factors to consider in the selection of the correct rivet for installation are: (1) Installation location, (2) composition of the material being riveted, (3) thickness of the material being riveted, and (4) strength desired.

If the rivet is to be installed on an aerodynamically smooth surface, or if clearance for an assembly is needed, countersunk head rivets should be selected. In other areas where clearance or smoothness is not a factor, the protruding head type rivet may be utilized.

Material composition of the rivet shank will depend upon the type of material being riveted. Aluminum alloy 2117 shank rivets can be used on most aluminum alloys. Aluminum alloy 5056 shank rivets should be used when the material being riveted is magnesium. Steel rivets should always be selected for riveting assemblies fabricated from steel.

The thickness of the material being riveted determines the overall length of the shank of the rivet. As a general rule, the shank of the rivet should extend beyond the material thickness approximately $\frac{3}{64}$ inch to $\frac{1}{8}$ inch before the stem is pulled (see figure 6-36).

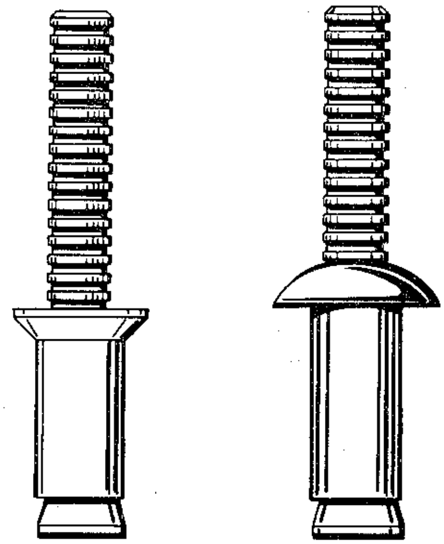


A – Thickness of material (grip range)

B – 3/64 - 1/8 Inch

C – Total rivet shank length

FIGURE 6–36. Determining length of friction lock rivets.



Countersunk head

Protruding head

FIGURE 6–37. Pull-thru rivets.

Pull-Thru Rivets

The pull-thru blind rivets are manufactured by several companies; the same general basic information about their fabrication, composition, uses, selection, installation, inspection, and removal procedures apply to all of them.

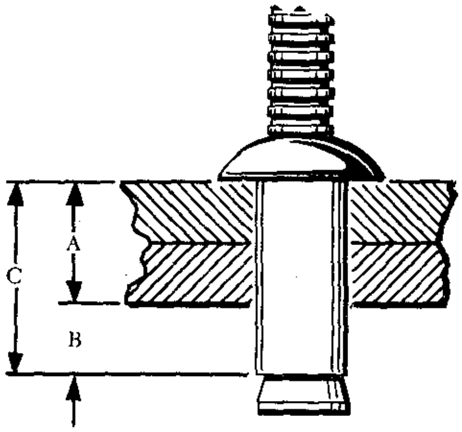
Pull-thru rivets are fabricated in two parts: A rivet head with a hollow shank or sleeve and a stem that extends through the hollow shank. Figure 6–37 illustrates a protruding head and a countersunk head pull-thru rivet.

Several events, in their proper sequence, occur when a pulling force is applied to the stem of the rivet: (1) The stem is pulled thru the rivet shank; (2) the mandrel portion of the stem forces the shank to expand forming the blind head and filling the hole.

Pull-thru rivets are fabricated in two common head styles: (1) Protruding head similar to the MS20470 or universal head, and (2) a 100° countersunk head. Other head styles are available from some manufacturers.

Pull-thru rivets are fabricated from several materials. Following are the most commonly used: 2117–T4 aluminum alloy, 5056 aluminum alloy, monel.

Pull-thru rivets are designed so that installation requires only one person; it is not necessary to have the work accessible from both sides.



A – Thickness of material (grip range)

B – 3/64 to 1/8 inch

C – Total rivet shank length

FIGURE 6–38. Determining length of pull-thru rivets.

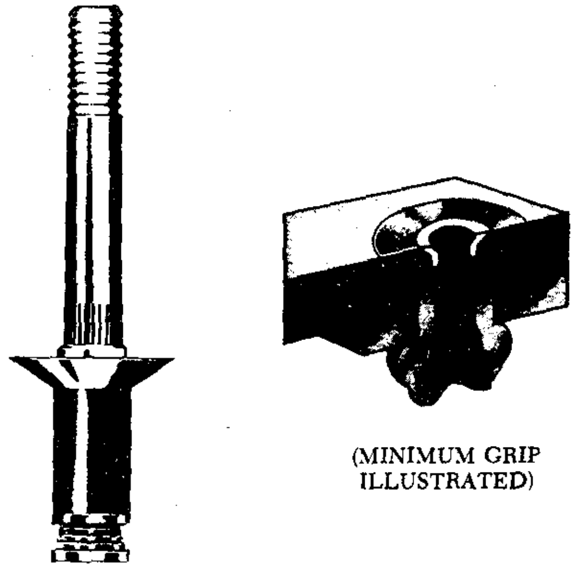


FIGURE 6–39. Bulbed cherrylock rivet.

Factors to consider in the selection of the correct rivet for installation are: (1) Installation location, (2) composition of the material being riveted, (3) thickness of the material being riveted, and (4) strength desired.

The thickness of the material being riveted determines the overall length of the shank of the rivet. As a general rule, the shank of the rivet should extend beyond the material thickness approximately $\frac{3}{64}$ inch to $\frac{1}{8}$ inch before the stem is pulled. See figure 6–38.

Each company that manufactures pull-thru rivets has a code number to help users obtain correct rivet for the grip range of a particular installation. In addition, MS numbers are used for identification purposes. Numbers are similar to those shown on the preceding page.

Self-Plugging Rivets

Self-plugging (mechanical lock) rivets are similar to self-plugging (friction lock) rivets, except for the manner in which the stem is retained in the rivet sleeve. This type of rivet has a positive mechanical locking collar to resist vibrations that cause the friction lock rivets to loosen and possibly fall out. (See figure 6–41.) Also, the mechanical locking type rivet stem breaks off flush with the head and usually does not require further stem trimming when properly installed. Self-plugging (mechanical lock) rivets display all the strength characteristics of solid shank rivets and in most cases can be substituted rivet for rivet.

Bulbed Cherrylock Rivets

The large blind head of this fastener introduced the word "bulb" to blind rivet terminology. In conjunction with the unique residual preload developed by the high stem break load, its proven fatigue strength makes it the only blind rivet interchangeable structurally with solid rivets (figure 6–39).

Wiredraw Cherrylock Rivets

A wide range of sizes, materials and strength levels to select from. This fastener is especially suited for sealing applications and joints requiring an excessive amount of sheet take-up (figure 6–40).

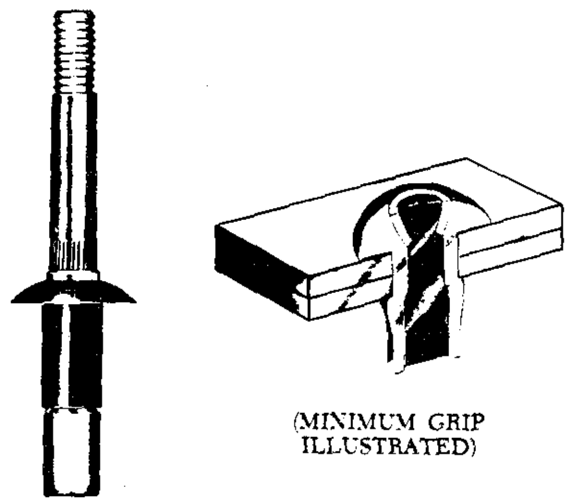


FIGURE 6–40. Wiredraw cherrylock rivet.

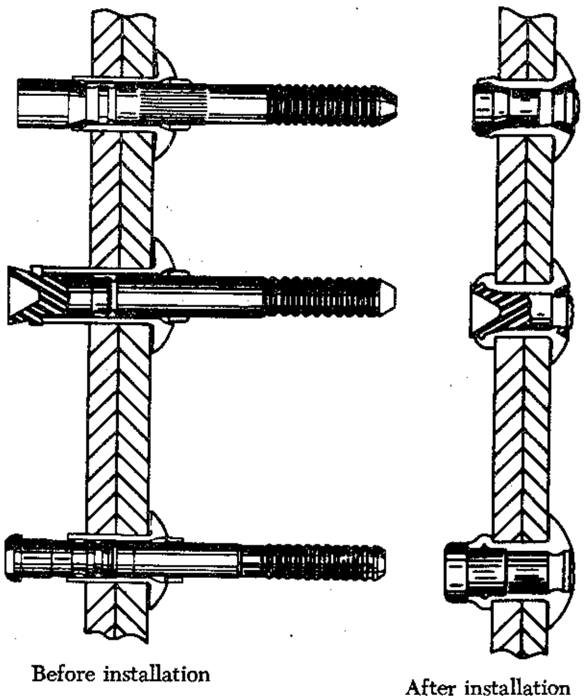


FIGURE 6–41. Self-plugging (mechanical lock) rivets.

Huck Mechanical Locked Rivets

Self-plugging (mechanical lock) rivets are fabricated in two sections—a head and shank (including a conical recess and locking collar in the head), and a serrated stem that extends through the shank. Unlike the friction lock rivet, the mechanical lock rivet has a locking collar that forms a positive lock for retention of the stem in the shank of the rivet. This collar is seated in position during the installation of the rivet.

Material

Self-plugging (mechanical lock) rivets are fabricated with sleeves (rivet shanks) of 2017 and 5056 aluminum alloys, monel, or stainless steel.

The mechanical lock type of self-plugging rivet can be used in the same applications as the friction lock type of rivet. In addition, because of its greater stem retention characteristic, installation in areas subject to considerable vibration is recommended.

The same general requirements must be met in the selection of the mechanical lock rivet as for the friction lock rivet. Composition of the material being joined together determines the composition of the rivet sleeve, for example, 2017 aluminum alloy rivets for most aluminum alloys and 5056 aluminum rivets for magnesium.

Figure 6–42 depicts the sequences of a typical mechanically locked blind rivet. The form and function may vary slightly between blind rivet styles and specifics should be obtained from manufacturers.

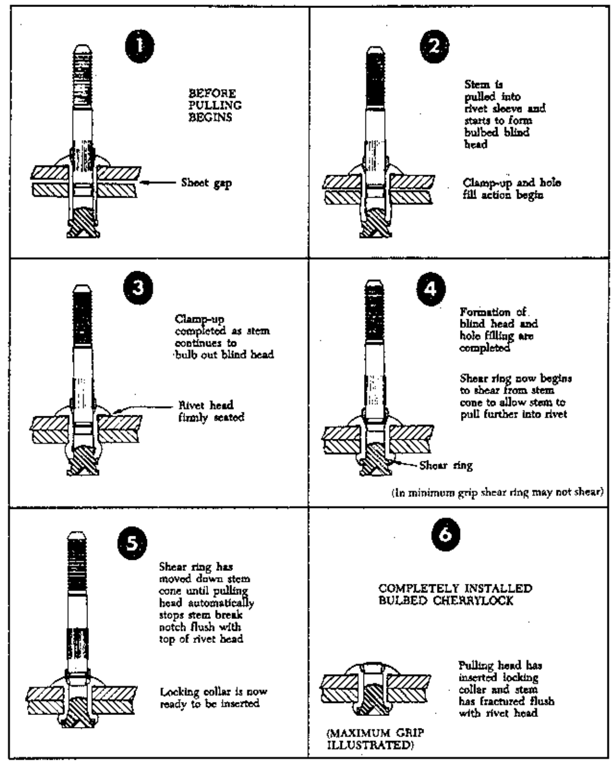


FIGURE 6–42. Cherrylock rivet installation.

Head Styles

Self-plugging mechanical locked blind rivets are available in several head styles (figure 6–43) depending on the installation requirements.

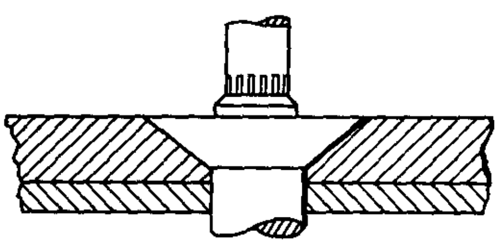
Diameters

Shank diameters are measured in $\frac{1}{32}$ inch increments and are generally identified by the first dash number: $\frac{3}{32}$ diameter $= -3$; $\frac{1}{8}$ diameter $= -4$; etc.

Both nominal and $\frac{1}{64}$ inch oversize diameters are available.

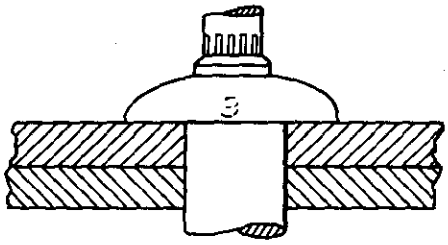
Grip Length

Grip length refers to the maximum total sheet thickness to be riveted and is measured in $\frac{1}{16}$ of an inch. This is generally identified by the second dash number. Unless otherwise noted, most blind rivets have their grip lengths (maximum grip)



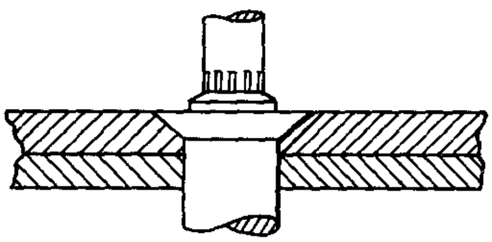
100° COUNTERSUNK
MS 20426

For countersunk applications.

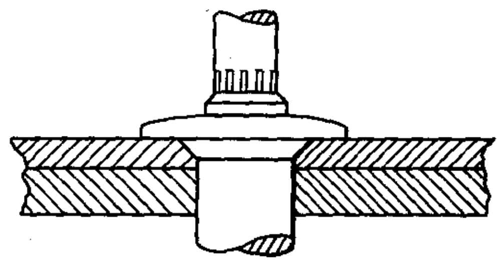


UNIVERSAL
MS 20470

For protruding head applications.

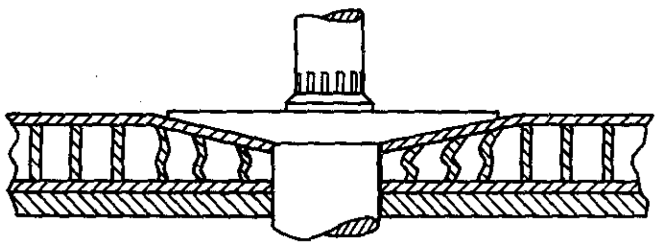


100° COUNTERSUNK
NAS 1097
For thin top sheet machine countersunk applications



UNISINK

A combination countersunk & protruding head for use in very thin top sheets. Strength equal to double-dimpling without the high cost.



156° COUNTERSUNK

A large diameter, shallow countersunk head providing wide bearing area for honey-comb applications.

FIGURE 6–43. Cherrylock rivet heads.

marked on the rivet head and have a total grip range of $\frac{1}{16}$ inch. Figure 6–44 demonstrates a typical grip accommodation.

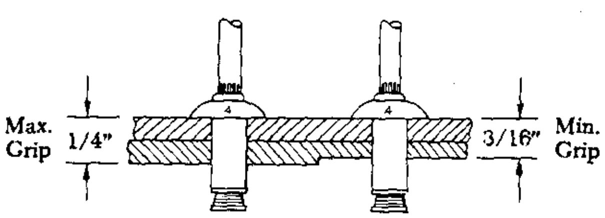


FIGURE 6–44. Typical grip length.

To determine the proper grip rivet to use, measure the material thickness with a grip selection gage (available from blind rivet manufacturers). The proper use of a grip selector gage is shown in figure 6–45.

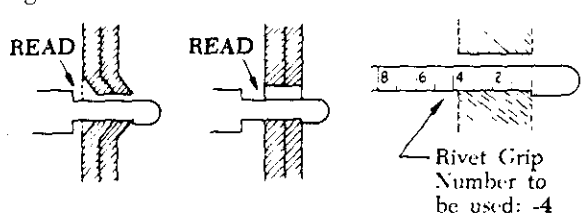
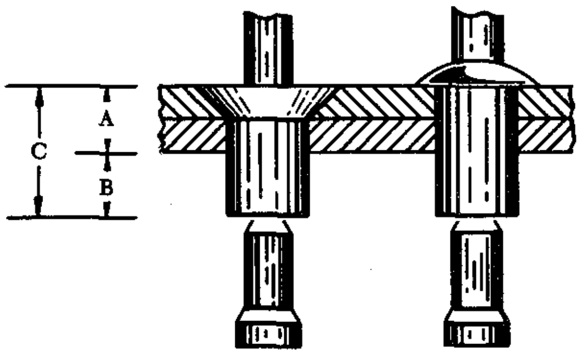


FIGURE 6–45. Grip gage use.



A – Thickness of material (grip range)

B – 3/64 to 1/8 inch

C – Total rivet shank length

FIGURE 6–46. Determining rivet length.

The thickness of the material being riveted determines the overall length of the shank of the rivet. As a general rule, the shank of the rivet should extend beyond the material thickness approximately $\frac{3}{64}$ inch to $\frac{1}{8}$ inch before the stem is pulled (see figure 6–46).

Rivet Identification

Each company that manufactures self-plugging (friction lock) rivets has a code number to help users obtain the correct rivet for the grip range or material thickness of a particular installation. In addition, MS numbers are used for identification purposes. The following examples of part numbers for self-plugging (friction lock) rivets are representative of each.

Huck Manufacturing Company—

9SP–B – A 6 – 3

Grip range (material thickness) in 16ths of an inch.

Shank diameter in 32nds of an inch:

4 = $\frac{1}{8}$ inch. 6 = $\frac{3}{16}$ inch.
5 = $\frac{5}{32}$ inch. 8 = $\frac{1}{4}$ inch.

Material composition of shank:

A = 2017 aluminum alloy.
B = 5056 aluminum alloy.
R = mild steel.

Head style:

9SP–B = brazier or universal head.
9SP–100 = 100° countersunk head.

Figure 6-47.

Olympic Screw and Rivet Corporation—

RV 2 0 0 – 4 – 2

Grip range in 16ths of an inch.

Shank diameter in 32nds of an inch:

4 = $\frac{1}{8}$ inch. 6 = $\frac{3}{16}$ inch.
5 = $\frac{5}{32}$ inch. 8 = $\frac{1}{4}$ inch.

Head style:

0 = universal head.
1 = 100° countersunk.

Material composition of shank:

0 = 2017 aluminum alloy.
5 = 5056 aluminum alloy.
7 = mild steel.

Rivet type:

2 = self-plugging (friction lock).
5 = hollow pull-thru.

Manufacturer:
Olympic Rivet and Screw Corporation.

Figure 6-48.

Townsend Company, Cherry Rivet Division—

CR 163 – 6 – 6

Grip range (material thickness): knob stem in 32nds of an inch; serrated stem in 16ths of an inch.

Rivet shank diameter in 32nds of an inch:

4 = $\frac{1}{8}$ inch. 6 = $\frac{3}{16}$ inch.
5 = $\frac{5}{32}$ inch. 8 = $\frac{1}{4}$ inch.

Series number:

Designates rivet material, type of rivet, and head style (163 = 2117 aluminum alloy, self-plugging (friction lock) rivet, protruding head).

Cherry Rivet.

Figure 6-49.

Military Standard Number—

MS *20600* *B* *4* *K* *2*

Grip range (material thickness) in ⅙ths of an inch.

Type of stem:
K = knot head stem.
W = serrated stem.

Shank diameter in 32nds of an inch:
4 = ⅛ inch. 6 = $\frac{3}{16}$ inch.
5 = $\frac{5}{32}$ inch. 8 = ¼ inch.

Material composition of sleeve:
AD = 2117 aluminum alloy.
B = 5056 aluminum alloy.

Type of rivet and head style:
20600 = self-plugging (friction lock) protruding head.
20601 = self-plugging (friction lock) 100° countersunk head.

Military Standard.

Figure 6-50.

Flat—0.32 Head Thickness		
6-45	6-75	6-100
8-45	8-75	8-100
10-45	10-75	10-100
6B45	6B75	6B100
8B45	8B75	8B100
10B45	10B75	10B100
6K45	6K75	6K100
8K45	8K75	8K100
10K45	10K75	10K100
6KB45	6KB75	6KB100
8KB45	8KB75	8KB100
10KB45	10KB75	10KB100
100°—0.48 Head Thickness		
6-91	6-121	6-146
8-91	8-121	8-146
10-91	10-121	10-146
6B91	6B121	6B146
8B91	8B121	8B146
10B91	10B121	10B146
100°—0.63 Head Thickness		
6-106	6-136	6-161
8-106	8-136	8-161
10-106	10-136	10-161
6B106	6B136	6B161
8B106	8B136	8B161
10B106	10B136	10B161
6K106	6K136	6K161
8K106	8K136	8K161
10K106	10K136	10K161
6KB106	6KB136	6KB161
8KB106	8KB136	8KB161
10KB106	10KB136	10KB161

FIGURE 6–51. Rivnut data chart.

Rivnuts

This is the trade name of a hollow, blind rivet made of 6053 aluminum alloy, counterbored and threaded on the inside. Rivnuts can be installed by one person using a special tool which heads the rivet on the blind side of the material. The Rivnut is threaded on the mandrel of the heading tool and inserted in the rivet hole. The heading tool is held at right angles to the material, the handle is squeezed, and the mandrel crank is turned clockwise after each stroke. Continue squeezing the handle and turning the mandrel crank of the heading tool until a solid resistance is felt, which indicates that the rivet is set.

The Rivnut is used primarily as a nut plate and in the attachment of deicer boots to the leading edges of wings. It may be used as a rivet in secondary structures or for the attachment of accessories such as brackets, instruments, or soundproofing materials.

Rivnuts are manufactured in two head types, each with two ends; the flat head with open or closed end, and the countersunk head with open or closed end. All Rivnuts, except the thin-head countersunk type, are available with or without small projections (keys) attached to the head to keep the Rivnut from turning. Keyed Rivnuts are used as a nut plate, while those without keys are used for straight blind riveting repairs where no torque loads are imposed. A keyway cutter is needed when installing Rivnuts which have keys.

The countersunk style Rivnut is made with two different head angles; the 100° with .048- and .063-inch head thickness, and the 115° with .063-inch head thickness. Each of these head styles is made in three sizes, 6–32, 8–32, and 10–32. These numbers represent the machine screw size of the threads on the inside of the Rivnut. The actual outside diameters of the shanks are $\frac{3}{16}$ inch for the 6–32 size, $\frac{7}{32}$ inch for the 8–32 size, and ¼ inch for the 10–32 size.

Open-end Rivnuts are the most widely used and are recommended in preference to the closed-end type wherever possible. However, closed-end Rivnuts must be used in pressurized compartments.

Rivnuts are manufactured in six grip ranges. The minimum grip length is indicated by a plain head, and the next higher grip length by one radial dash mark on the head. Each succeeding grip range is indicated by an additional radial dash mark until five marks indicate the maximum range.

Notice in figure 6–51 that some part number codes consist of a "6", an "8", or a "10", a "dash", and two or three more numbers. In some, the dash is replaced by the letters "K" or "KB". The first number indicates the machine screw size of the thread, and the last two or three numbers indicate the maximum grip length in thousandths of an inch. A dash between the figures indicates that the Rivnut has an open end and is keyless; a "B" in place of the dash means it has a closed end and is keyless; a "K" means it is an open end and has a key; and a "KB" indicates that it has a closed end and a key. If the last two or three numbers are divisible by five, the Rivnut has a flathead; if they are not divisible by five, the Rivnut has a countersunk head.

An example of a part number code is:

10 KB 106

- 106 — Grip length.
- KB — Closed end and key.
- 10 — Screw and thread size.

Dill Lok-Skrus and Dill Lok-Rivets

Dill "Lok-Skru" and "Lok-Rivet" (see figure 6–52) are trade names for internally threaded rivets. They are used for blind attachment of such accessories as fairings, fillets, access door covers, door and window frames, floor panels, and the like. Lok-Skrus and Lok-Rivets are similar to the Rivnut in appearance and application; however, they come in two parts and require more clearance on the blind side than the Rivnut to accommodate the barrel.

The Lok-Rivet and the Lok-Skru are alike in construction, except the Lok-Skru is tapped internally for fastening an accessory by using an attaching screw, whereas the Lok-Rivet is not tapped and can be used only as a rivet. Since both Lok-Skrus and Lok-Rivets are installed in the same manner, the following discussion for the Lok-Skru also applies to the Lok-Rivet.

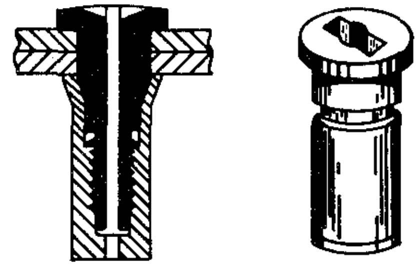


FIGURE 6–52. Internally threaded rivet

The main parts of a Lok-Skru are the barrel, the head, and an attachment screw. The barrel is made of aluminum alloy and comes in either closed or open ends. The head is either aluminum alloy or steel, and the attachment screw is made of steel. All of the steel parts are cadmium plated, and all of the aluminum parts are anodized to resist corrosion. When installed, the barrel screws up over the head and grips the metal on the blind side. The attaching screw is then inserted if needed. There are two head types, the flathead and the countersunk head. The Lok-Skru is tapped for 7–32, 8–32, 10–32, or 10–24 screws, and the diameters vary from .230 inch for 6–32 screws, to .292 inch for 10–32 screws. Grip ranges vary from .010 inch to .225 inch.

Deutsch Rivets

This rivet is a high-strength blind rivet used on late model aircraft. It has a minimum shear strength of 75,000 p.s.i., and can be installed by one man.

The Deutsch rivet consists of two parts, the stainless steel sleeve and the hardened steel drive pin (see figure 6–53). The pin and sleeve are coated with a lubricant and a corrosion inhibitor.

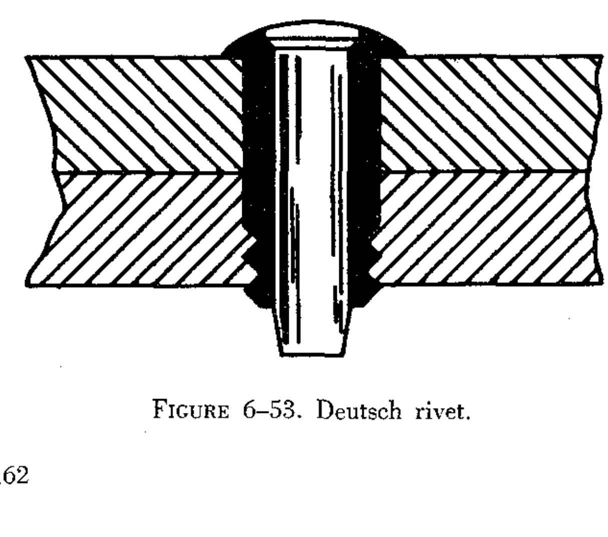


FIGURE 6–53. Deutsch rivet.

The Deutsch rivet is available in diameters of $\frac{3}{16}$, $\frac{1}{4}$, or $\frac{3}{8}$ inch. Grip lengths for this rivet range from $\frac{3}{16}$ to 1 inch. Some variation is allowed in grip length when installing the rivet; for example, a rivet with a grip length of $\frac{3}{16}$ inch can be used where the total thickness of materials is between 0.198 and 0.228 inch.

When driving a Deutsch rivet, an ordinary hammer or a pneumatic rivet gun and a flathead set are used. The rivet is seated in the previously drilled hole and then the pin is driven into the sleeve. The driving action causes the pin to exert pressure against the sleeve and forces the sides of the sleeve out. This stretching forms a shop head on the end of the rivet and provides positive fastening. The ridge on the top of the rivet head locks the pin into the rivet as the last few blows are struck.

Pin Rivets

Pin (Hi-shear) rivets are classified as special rivets but are not of the blind type. Access to both sides of the material is required to install this type of rivet. Pin rivets have the same shear strength as bolts of equal diameters, are about 40 percent of the weight of a bolt, and require only about one-fifth as much time for installation as a bolt, nut, and washer combination. They are approximately three times as strong as solid-shank rivets.

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 effecting a firm, tight fit (see figure 6–54).

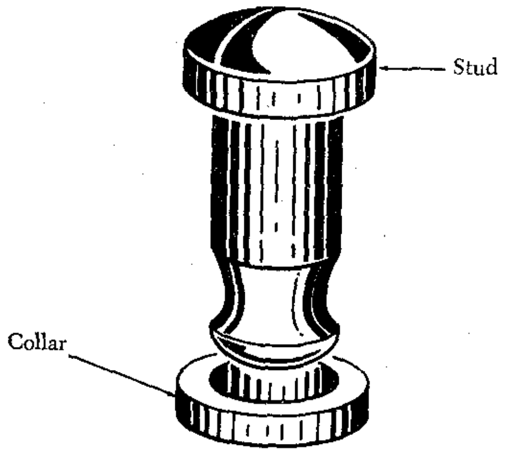


FIGURE 6–54. Pin (Hi-shear) rivet.

Pin rivets are fabricated in a variety of materials but should be used only in shear applications. They should never be used where the grip length is less than the shank diameter.

Part numbers for pin rivets can be interpreted to give the diameter and grip length of the individual rivets. A typical part number breakdown would be:

NAS 177 – 14 – 17

- 17 — Maximum grip length in 16ths of an inch.
- 14 — Nominal diameter in 32nds of an inch.
- 177 = 100° countersunk head rivet.
- 178 = flathead rivet.
- NAS — National Aircraft Standard.

PLASTICS

Plastics are used in many applications throughout modern aircraft. These applications range from structural components of thermosetting plastics reinforced with fiber glass to decorative trim of thermoplastic materials.

Transparent Plastics

Transparent plastic materials used in aircraft canopies, windshields, and other similar transparent enclosures may be divided into two major classes or groups. These plastics are classified according to their reaction to heat. The two classes are *Thermoplastic* and *Thermosetting*.

Thermoplastic materials will soften when heated and harden when cooled. These materials can be heated until soft, and then formed into the desired shape. When cooled, they will retain this shape. The same piece of plastic can be reheated and reshaped any number of times without changing the chemical composition of the material.

Thermosetting plastics harden upon heating, and reheating has no softening effect. These plastics cannot be reshaped after once being fully cured by the application of heat.

In addition to the above classes, transparent plastics are manufactured in two forms, monolithic (solid) and laminated. Laminated transparent plastics are made from transparent plastic face sheets bonded by an inner-layer material, usually polyvinyl butyral. Because of its shatter-resistant qualities, laminated plastic is superior to solid plastics and is used in many pressurized aircraft. Most of the transparent sheet used in aviation is manufactured in accordance with various military specifications.

A new development in transparent plastics is stretched acrylic. Stretched acrylic is a type of plastic which, before being shaped, is pulled in both directions to rearrange its molecular structure. Stretched acrylic panels have a greater resistance to impact and are less subject to shatter; its chemical resistance is greater, edging is simpler, and crazing and scratches are less detrimental.

Individual sheets of plastic are covered with a heavy masking paper to which a pressure-sensitive adhesive has been added. This paper helps to prevent accidental scratching during storage and handling. Care should be taken to avoid scratches and gouges which may be caused by sliding sheets against one another or across rough or dirty tables.

Sheets should be stored in bins which are tilted at approximately 10° from vertical, if possible. If they must be stored horizontally, piles should not be over 18 inches high, and small sheets should be stacked on the larger ones to avoid unsupported overhang. Storage should be in a cool, dry place away from solvent fumes, heating coils, radiators, and steampipes. The temperature in the storage room should not exceed 120° F.

While direct sunlight does not harm acrylic plastic, it will cause drying and hardening of the masking adhesive, making removal of the paper difficult. If the paper will not roll off easily, place the sheet in an oven at 250° F. for 1 minute, maximum. The heat will soften the masking adhesive for easy removal of the paper.

If an oven is not available, hardened masking paper may be removed by softening the adhesive with aliphatic naphtha. Rub the masking paper with a cloth saturated with naphtha. This will soften the adhesive and free the paper from the plastic. Sheets so treated must be washed immediately with clean water, taking care not to scratch the surfaces.

NOTE: Aliphatic naphtha is not to be confused with aromatic naphtha and other dry-cleaning solvents which are definitely harmful in their effects on plastic. However, aliphatic naphtha is flammable and all precautions regarding the use of flammable liquids must be observed.

Reinforced Plastic

Reinforced plastic is a thermosetting material used in the manufacture of radomes, antenna covers, and wingtips, and as insulation for various pieces of electrical equipment and fuel cells. It has excellent dielectric characteristics which make it ideal for radomes; however, its high strength-weight ratio, resistance to mildew, rust, and rot, and ease of fabrication make it equally suited for other parts of the aircraft.

Reinforced plastic components of aircraft are formed of either solid laminates or sandwich-type laminates. Resins used to impregnate glass cloths are of the contact-pressure type (requiring little or no pressure during cure). These resins are supplied as a liquid which can vary in viscosity from a waterlike consistency to a thick sirup. Cure or polymerization is effected by the use of a catalyst, usually benzoyl peroxide.

Solid laminates are constructed of three or more layers of resin-impregnated cloths "wet laminated" together to form a solid sheet facing or molded shape.

Sandwich-type laminates are constructed of two or more solid sheet facings or a molded shape enclosing a fiberglass honeycomb- or foam-type core. Honeycomb cores are made of glass cloths impregnated with a polyester or a combination of nylon and phenolic resins. The specific density and cell size of honeycomb cores varies over a considerable latitude. Honeycomb cores are normally fabricated in blocks that are later cut to the desired thickness on a bandsaw.

Foam-type cores are formulated from combinations of alkyd resins and metatoluene di-isocyanate. Sandwich-type fiberglass components filled with foam-type cores are manufactured to exceedingly close tolerances on overall thickness of the molded facing and core material. To achieve this accuracy, the resin is poured into a close-tolerance, molded shape. The resin formulation immediately foams up to fill the void in the molded shape and forms a bond between the facing and the core.

RUBBER

Rubber is used to prevent the entrance of dirt, water, or air, and to prevent the loss of fluids, gases, or air. It is also used to absorb vibration, reduce noise, and cushion impact loads.

The term "rubber" is as all-inclusive as the term "metal." It is used to include not only natural rubber, but all synthetic and silicone rubbers.

Natural Rubber

Natural rubber has better processing and physical properties than synthetic or silicone rubber. These properties include: Flexibility, elasticity, tensile strength, tear strength, and low heat buildup due to flexing (hysteresis). Natural rubber is a general-purpose product; however, its suitability for aircraft use is somewhat limited because of its inferior resistance to most influences that cause deterioration. Although it provides an excellent seal for many applications, it swells and often softens in all aircraft fuels and in many solvents (naphthas, etc.). Natural rubber deteriorates more rapidly than synthetic rubber. It is used as a sealing material for water/methanol systems.

Synthetic Rubber

Synthetic rubber is available in several types, each of which is compounded of different materials to give the desired properties. The most widely used are the butyls, Bunas, and neoprene.

Butyl is a hydrocarbon rubber with superior resistance to gas permeation. It is also resistant to deterioration; however, its comparative physical properties are significantly less than those of natural rubber. Butyl will resist oxygen, vegetable oils, animal fats, alkalies, ozone, and weathering.

Like natural rubber, butyl will swell in petroleum or coal tar solvents. It has a low water-absorption rate and good resistance to heat and low temperature. Depending on the grade, it is suitable for use in temperatures ranging from −65° F. to 300° F. Butyl is used with phosphate ester hydraulic fluids (Skydrol), silicone fluids, gases, ketones, and acetones.

Buna-S rubber resembles natural rubber both in processing and performance characteristics. Buna-S is as water-resistant as natural rubber, but has somewhat better aging characteristics. It has good resistance to heat, but only in the absence of severe flexing. Generally, Buna-S has poor resistance to gasoline, oil, concentrated acids, and solvents. Buna-S is normally used for tires and tubes as a substitute for natural rubber.

Buna-N is outstanding in its resistance to hydrocarbons and other solvents; however, it has poor resilience in solvents at low temperature. Buna-N compounds have good resistance to temperatures up to 300° F., and may be procured for low temperature applications down to −75° F. Buna-N has fair tear, sunlight, and ozone resistance. It has good abrasion resistance and good breakaway properties when used in contact with metal. When used as a seal on a hydraulic piston, it will not stick to the cylinder wall. Buna-N is used for oil and gasoline hose, tank linings, gaskets, and seals.

Neoprene can take more punishment than natural rubber and has better low-temperature characteristics. It possesses exceptional resistance to ozone, sunlight, heat, and aging. Neoprene looks and feels like rubber. Neoprene, however, is less like rubber in some of its characteristics than butyl or Buna. The physical characteristics of neoprene, such as tensile strength and elongation, are not equal to natural rubber but do have a definite similarity. Its tear resistance as well as its abrasion resistance is slightly less than that of natural rubber. Although its distortion recovery is complete, it is not as rapid as natural rubber.

Neoprene has superior resistance to oil. Although it is good material for use in nonaromatic gasoline systems, it has poor resistance to aromatic gasolines. Neoprene is used primarily for weather seals, window channels, bumper pads, oil-resistant hose, and carburetor diaphragms. It is also recommended for use with Freons and silicate ester lubricants.

Thiokol, known also as polysulfide rubber, has the highest resistance to deterioration but ranks the lowest in physical properties. Thiokol, in general, is not seriously affected by petroleum, hydrocarbons, esters, alcohols, gasoline, or water. Thiokols are ranked low in such physical properties as compression set, tensile strength, elasticity, and tear abrasion resistance. Thiokol is used for oil hose, tank linings for aromatic aviation gasolines, gaskets, and seals.

Silicone rubbers are a group of plastic rubber materials made from silicon, oxygen, hydrogen, and carbon. The silicons have excellent heat stability and very low temperature flexibility. They are suitable for gaskets, seals, or other applications where elevated temperatures up to 600° F. are prevalent. Silicone rubbers are also resistant to temperatures down to −150° F. Throughout this temperature range, silicone rubber remains extremely flexible and useful with no hardness or gumminess. Although this material has good resistance to oils, it reacts unfavorably to both aromatic and nonaromatic gasolines.

Silastic, one of the best known silicones, is used to insulate electrical and electronic equipment. Because of its dielectric properties over a wide range of temperatures, it remains flexible and free from crazing and cracking. Silastic is also used for gaskets and seals in certain oil systems.

SHOCK ABSORBER CORD

Shock absorber cord is made from natural rubber strands encased in a braided cover of woven cotton cords treated to resist oxidation and wear. Great tension and elongation are obtained by weaving the jacket upon the bundle of rubber strands while they are stretched about three times their original length.

There are two types of elastic shock-absorbing cord. Type I is a straight cord, and type II is a continuous ring, known as a "bungee." The advantages of the type II cord are that they are easily and quickly replaced and do not have to be secured by stretching and whipping. Shock cord is available in standard diameters from 1/4 inch to 13/16 inch.

Three colored threads are braided into the outer cover for the entire length of the cord. Two of these threads are of the same color and represent the year of manufacture; the third thread, a different color, represents the quarter of the year in which the cord was made. The code covers a 5-year period and then repeats itself. This makes it easy to figure forward or backward from the years shown in figure 6–55.

Year marking

Year	Threads	Color
1968	2	blue
1969	2	yellow
1970	2	black
1971	2	green
1972	2	red

Quarter marking

Quarter	Threads	Color
Jan., Feb., Mar.	1	red
Apr., May, June	1	blue
July, Aug., Sept.	1	green
Oct., Nov., Dec.	1	yellow

FIGURE 6–55. Shock absorber cord color coding.

SEALS

Seals are used to prevent fluid from passing a certain point, as well as to keep air and dirt out of the system in which they are used. The increased use of hydraulics and pneumatics in aircraft systems has created a need for packings and gaskets of varying characteristics and design to meet the many variations of operating speeds and temperatures to which they are subjected. No one style or type of seal is satisfactory for all installations. Some of the reasons for this are: (1) Pressure at which the system operates, (2) the type fluid used in the system, (3) the metal finish and the clearance between adjacent parts, and (4) the type motion (rotary or reciprocating), if any. Seals are divided into three main classes: (1) Packings, (2) gaskets, and (3) wipers.

Packings

Packings are made of synthetic or natural rubber. They are generally used as "running seals," that is, in units that contain moving parts, such as actuating cylinders, pumps, selector valves, etc. Packings are made in the form of O-rings, V-rings, and U-rings, each designed for a specific purpose. (See figure 6–56.)

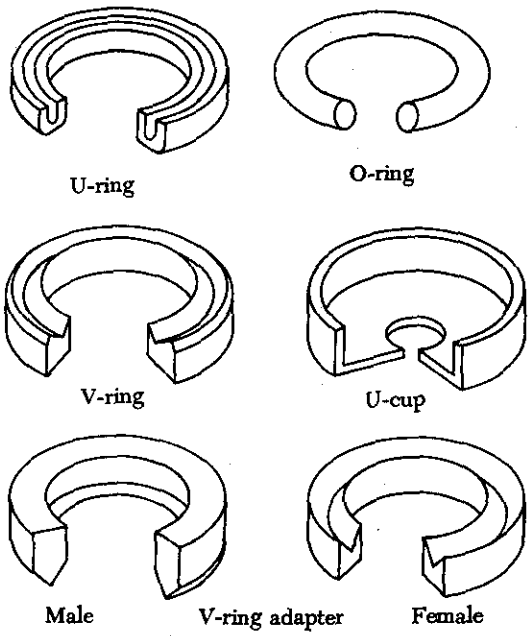


FIGURE 6-56. Packing rings.

O-Ring Packings

O-ring packings are used to prevent both internal and external leakage. This type of packing ring seals effectively in both directions and is the type most commonly used. In installations subject to pressures above 1,500 p.s.i., backup rings are used with O-rings to prevent extrusion.

When an O-ring packing is to be subjected to pressure from both sides, as in actuating cylinders, two backup rings must be used (one on either side of the O-ring). When an O-ring is subject to pressure on only one side, a single backup ring is generally used. In this case the backup ring is always placed on the side of the O-ring away from the pressure.

The materials from which O-rings are manufactured have been compounded for various operating conditions, temperatures, and fluids. An O-ring designed specifically as a static (stationary) seal will probably not do the job when installed on a moving part such as a hydraulic piston. Most O-rings are similar in appearance and texture, but their characteristics may differ widely. An O-ring will be useless if it is not compatible with the system fluid and operating temperature.

Advances in aircraft design have necessitated new O-ring compositions to meet changed operating conditions. Hydraulic O-rings were originally established under AN specification numbers (6227, 6230, and 6290) for use in MIL-H-5606 fluid at temperatures ranging from −65° F. to +160° F. When new designs raised operating temperatures to a possible 275° F., more compounds were developed and perfected.

Recently a compound was developed that offered improved low-temperature performance without sacrificing high-temperature performance, rendering the other series obsolete. This superior material was adopted in the MS28775 series. This series is now the standard for MIL-H-5606 systems where the temperature may vary from −65° F. to +275° F.

Manufacturers provide color coding on some O-rings, but this is not a reliable or complete means of identification. The color coding system does not identify sizes, but only system fluid or vapor compatibility and in some cases the manufacturer. Color codes on O-rings that are compatible with MIL-H-5606 fluid will always contain blue, but may also contain red or other colors. Packings and gaskets suitable for use with Skydrol fluid will always be coded with a green stripe, but may also have a blue, grey, red, green, or yellow dot as a part of the color code. Color codes on O-rings that are compatible with hydrocarbon fluid will always contain red, and will never contain blue. A colored stripe around the circumference indicates that the O-ring is a boss gasket seal. The color of the stripe indicates fluid compatibility: red for fuel, blue for hydraulic fluid.

The coding on some rings is not permanent. On others it may be omitted due to manufacturing difficulties or interference with operation. Furthermore, the color coding system provides no means to establish the age of the O-ring or its temperature limitations.

Because of the difficulties with color coding, O-rings are available in individual hermetically sealed envelopes, labeled with all pertinent data. When selecting an O-ring for installation, the basic part number on the sealed envelope provides the most reliable compound identification.

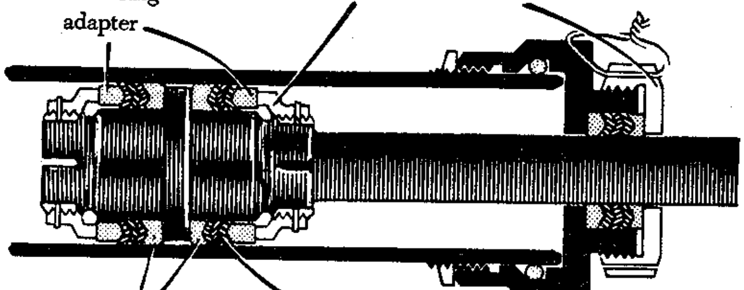


FIGURE 6–57. V-ring installation.

Although an O-ring may appear perfect at first glance, slight surface flaws may exist. These flaws are often capable of preventing satisfactory O-ring performance under the variable operating pressures of aircraft systems; therefore, O-rings should be rejected for flaws that will affect their performance. Such flaws are difficult to detect, and one aircraft manufacturer recommends using a 4-power magnifying glass with adequate lighting to inspect each ring before it is installed.

By rolling the ring on an inspection cone or dowel, the inner diameter surface can also be checked for small cracks, particles of foreign material, or other irregularities that will cause leakage or shorten the life of the O-ring. The slight stretching of the ring when it is rolled inside out will help to reveal some defects not otherwise visible.

Backup Rings

Backup rings (MS28782) made of Teflon do not deteriorate with age, are unaffected by any system fluid or vapor, and can tolerate temperature extremes in excess of those encountered in high-pressure hydraulic systems. Their dash numbers indicate not only their size but also relate directly to the dash number of the O-ring for which they are dimensionally suited. They are procurable under a number of basic part numbers, but they are interchangeable; that is, any Teflon backup ring may be used to replace any other Teflon backup ring if it is of proper overall dimension to support the applicable O-ring. Backup rings are not color coded or otherwise marked and must be identified from package labels.

The inspection of backup rings should include a check to ensure that surfaces are free from irregularities, that the edges are clean-cut and sharp, and that scarf cuts are parallel. When checking Teflon spiral backup rings, make sure that the coils do not separate more than 1/4 inch when unrestrained.

V-Ring Packings

V-ring packings (AN6225) are one-way seals and are always installed with the open end of the "V" facing the pressure. V-ring packings must have a male and female adapter to hold them in the proper position after installation. It is also necessary to torque the seal retainer to the value specified by the manufacturer of the component being serviced, or the seal may not give satisfactory service. An installation using V-rings is shown in figure 6–57.

U-Ring Packings

U-ring packings (AN6226) and U-cup packings are used in brake assemblies and brake master cylinders. The U-ring and U-cup will seal pressure in only one direction; therefore, the lip of the packings must face toward the pressure. U-ring packings are primarily low-pressure packings to be used with pressures of less than 1,000 p.s.i.

GASKETS

Gaskets are used as static (stationary) seals between two flat surfaces. Some of the more common gasket materials are asbestos, copper, cork, and rubber. Asbestos sheeting is used wherever a heat-resistant gasket is needed. It is used extensively for exhaust system gaskets. Most asbestos exhaust gaskets have a thin sheet of copper edging to prolong their life.

A solid copper washer is used for spark plug gaskets where it is essential to have a noncompressible yet semisoft gasket.

Cork gaskets can be used as an oil seal between the engine crankcase and accessories, and where a gasket is required that is capable of occupying an uneven or varying space caused by a rough surface or expansion and contraction.

Rubber sheeting can be used where there is a need for a compressible gasket. It should not be used in any place where it may come in contact with gasoline or oil because the rubber will deteriorate very rapidly when exposed to these substances.

Gaskets are used in fluid systems around the end caps of actuating cylinders, valves, and other units. The gasket generally used for this purpose is in the shape of an O-ring, similar to O-ring packings.

WIPERS

Wipers are used to clean and lubricate the exposed portions of piston shafts. They prevent dirt from entering the system and help protect the piston shaft against scoring.

Wipers may be either the metallic or the felt type. They are sometimes used together, with the felt wiper installed behind the metallic wiper.

SEALING COMPOUNDS

Certain areas of all aircraft are sealed to withstand pressurization by air, to prevent leakage of fuel, to prevent passage of fumes, or to prevent corrosion by sealing against the weather. Most sealants consist of two or more ingredients properly proportioned and compounded to obtain the best results. Some materials are ready for use as packaged, but others will require mixing before application.

One-Part Sealants

One-part sealants are prepared by the manufacturer and are ready for application as packaged. However, the consistency of some of these compounds may be altered to satisfy a particular method of application. If thinning is desired, the thinner recommended by the sealant manufacturer should be used.

Two-Part Sealants

Two-part sealants are compounds requiring separate packaging to prevent cure prior to application and are identified as the base sealing compound and the accelerator. Any alteration of the prescribed ratios will reduce the quality of the material. Generally two-part sealants are mixed by combining equal portions (by weight) of base compound and accelerator.

All sealant material should be carefully weighed in accordance with the sealant manufacturer's recommendations. Sealant material is usually weighed with a balance scale equipped with weights specially prepared for various quantities of sealant and accelerator.

Before weighing the sealant materials, both the base sealant compound and the accelerator should be thoroughly stirred. Accelerator which is dried out, lumpy, or flaky should not be used. Preweighed sealant kits do not require weighing of the sealant and accelerator before mixing when the entire quantity is to be mixed.

After the proper amount of base sealant compound and accelerator has been determined, add the accelerator to the base sealant compound. Immediately after adding the accelerator, thoroughly mix the two parts by stirring or folding, depending on the consistency of the material. The material should be mixed carefully to prevent entrapment of air in the mixture. Too rapid or prolonged stirring must be avoided as it will build up heat in the mixture and will shorten the normal application time (working life) of the mixed sealant.

To ensure a well-mixed compound, it may be tested by smearing a small portion on a clean, flat metal or glass surface. If flecks or lumps are found, continue mixing. If the flecks or lumps cannot be eliminated, the batch should be rejected.

The working life of mixed sealant is from one-half hour to 4 hours (depending upon the class of sealant); therefore, mixed sealant should be applied as soon as possible or placed in refrigerated storage. Figure 6–58 presents general information concerning various sealants.

The curing rate of mixed sealants varies with changes in temperature and humidity. Curing of sealants will be extremely slow if the temperature

Sealant Base	Accelerator (catalyst)	Mixing ratio by weight	Application life (work)	Storage (shelf) life after mixing	Storage (shelf) life unmixed	Temperature range	Application and limitations
EC-801 (black) MIL-S-7502A Class B-2.	EC-807.	12 parts of EC-807 to 100 parts of EC-801.	2-4 hours.	5 days at –20°F. after flash freeze at –65°F.	6 months.	–65°F. to 200°F.	Faying surfaces, fillet seals, and packing gaps.
EC-800 (red)	None.	Use as is.	8-12 hours.	Not applicable.	6-9 months.	–65°F. to 200°F.	Coating rivets.
EC-612 P (pink) MIL-P-20628.	None.	Use as is.	Indefinite non-drying.	Not applicable.	6-9 months.	–40°F. to 200°F.	Packing voids up to 1/4 inch.
PR-1302HT (red) MIL-S-8784.	PR-1302HT-A.	10 parts of PR-1302HT-A to 100 parts of PR-1302HT.	2-4 hours.	5 days at –20°F. after flash freeze at –65°F.	6 months.	–65°F. to 200°F.	Sealing access door gaskets.
PR-727 potting compound MIL-S-8516B.	PR-727A.	12 parts of PR-727A to 100 parts of PR-727.	1½ hours minimum.	5 days at –20°F. after flash freeze at –65°F.	6 months.	–65°F. to 200°F.	Potting electrical connections and bulkhead seals.
HT-3 (greygreen)	None.	Use as is.	Solvent release, sets up in 2 to 4 hours.	Not applicable.	6 to 9 months.	–60°F. to 850°F.	Sealing hot air ducts passing through bulkheads.
EC-776 (clear amber) MIL-S-4383B.	None.	Use as is.	8-12 hours.	Not applicable.	Indefinite in airtight containers.	–65°F. to 250°F.	Top coating.

FIGURE 6–58. General sealant information.

is below 60° F. A temperature of 77° F. with 50 percent relative humidity is the ideal condition for curing most sealants.

Curing may be accelerated by increasing the temperature, but the temperature should never be allowed to exceed 120° F. at any time in the curing cycle. Heat may be applied by using infrared lamps or heated air. If heated air is used, it must be properly filtered to remove moisture and dirt.

Heat should not be applied to any faying surface sealant installation until all work is completed. All faying surface applications must have all attachments, permanent or temporary, completed within the application limitations of the sealant.

Sealant must be cured to a tack-free condition before applying brush top coatings. (Tack-free consistency is the point at which a sheet of cellophane pressed onto the sealant will no longer adhere.)

CORROSION CONTROL

Metal corrosion is the deterioration of the metal by chemical or electrochemical attack and can take place internally as well as on the surface. As in the rotting of wood, this deterioration may change the smooth surface, weaken the interior, or damage or loosen adjacent parts.

Water or water vapor containing salt combine with oxygen in the atmosphere to produce the main source of corrosion in aircraft. Aircraft operating in a marine environment or in areas where the atmosphere contains industrial fumes which are corrosive are particularly susceptible to corrosive attacks.

Corrosion can cause eventual structural failure if left unchecked. The appearance of the corrosion varies with the metal. On aluminum alloys and magnesium it appears as surface pitting and etching, often combined with a grey or white powdery deposit. On copper and copper alloys the corrosion forms a greenish film; on steel a reddish rust. When the grey, white, green, or reddish deposits are removed, each of the surfaces may appear etched and pitted, depending upon the length of exposure and severity of attack. If these surface pits are not too deep, they may not significantly alter the strength of the metal; however, the pits may become sites for crack development. Some types of corrosion can travel beneath surface coatings and can spread until the part fails.

Types of Corrosion

There are two general classifications of corrosion which cover most of the specific forms. These are direct chemical attack and electrochemical attack. In both types of corrosion the metal is converted into a metallic compound such as an oxide, hydroxide, or sulfate. The corrosion process always involves two simultaneous changes: The metal that is attacked or oxidized suffers what may be called anodic change, and the corrosive agent is reduced and may be considered as undergoing cathodic change.

Direct Chemical Attack

Direct chemical attack, or pure chemical corrosion, is an attack resulting from a direct exposure of a bare surface to caustic liquid or gaseous agents. Unlike electrochemical attack where the anodic and cathodic changes may be taking place a measurable distance apart, the changes in direct chemical attack are occurring simultaneously at the same point. The most common agents causing direct chemical attack on aircraft are: (1) Spilled battery acid or fumes from batteries; (2) residual flux deposits resulting from inadequately cleaned, welded, brazed, or soldered joints; and (3) entrapped caustic cleaning solutions. Spilled battery acid is becoming less of a problem with the advent of aircraft using nickel-cadmium batteries which are usually closed units. The use of these closed units lessens the hazards of acid spillage and battery fumes.

Many types of fluxes used in brazing, soldering, and welding are corrosive and they chemically attack the metals or alloys with which they are used. Therefore, it is important that residual flux be removed from the metal surface immediately after the joining operation. Flux residues are hygroscopic in nature; that is, they are capable of absorbing moisture, and unless carefully removed, tend to cause severe pitting.

Caustic cleaning solutions in concentrated form should be kept tightly capped and as far from aircraft as possible. Some cleaning solutions used in corrosion removal are, in themselves, potentially corrosive agents, and particular attention should be directed toward their complete removal after use on aircraft. Where entrapment of the cleaning solution is likely to occur, a noncorrosive cleaning agent should be used even though it is less efficient.