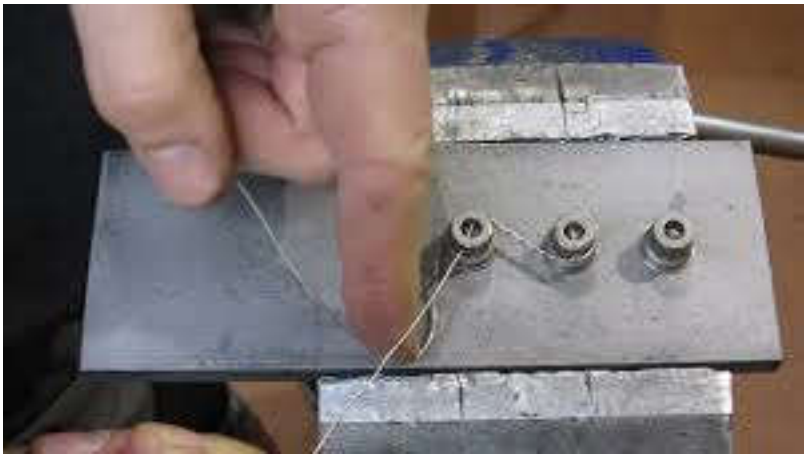
TRAINING MANUAL
LOCKWIRE, FASTENERS & HARDWARE COURSE



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Lock Wiring/Safety Wiring

WHAT IS SAFETY/LOCK WIRING?

To start this course, watch the following Youtube video.

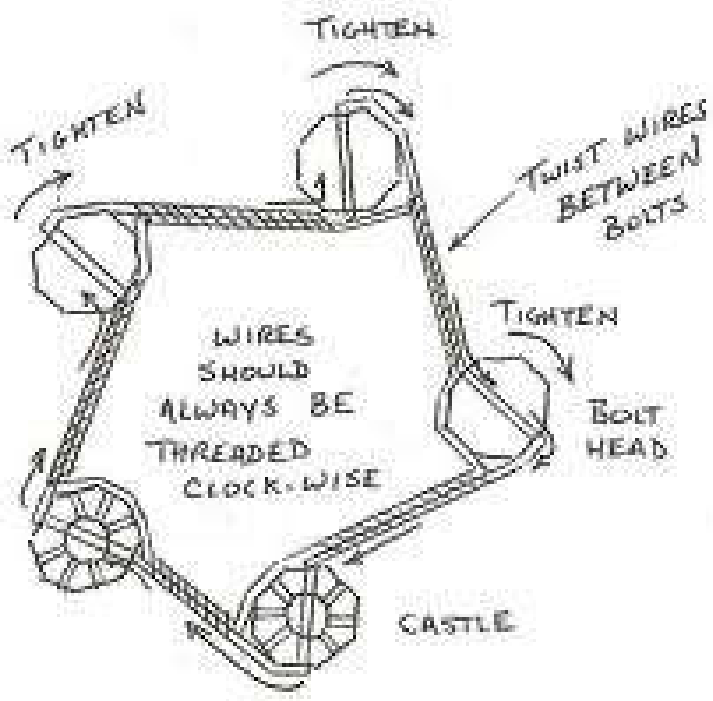
http://www.youtube.com/watch?v=OwFjUX6SaY8

Aerospace components are required to remain securely in position despite extreme changes in temperature, high vibration levels and prolonged periods of use. Special fasteners, mechanical locks and torquing are often used to ensure that things remain tight but for some purposes these techniques are just not reliable enough. In these special cases a technique called safety or lock wiring is used. When properly done, this technique will guarantee that fasteners and components do not loosen despite changes in the operating environment. In addition to its reliability lock wiring is simple to learn and cost efficient to use.

Lock wiring may be used on nuts, bolts, valves, turnbuckles or on any component that has been drilled or shaped to accept the locking wire.

Lock wire is comprised of stainless steel (for temperatures up to 700^0 F) or Inconel (for temperatures up to 1800^0 F).

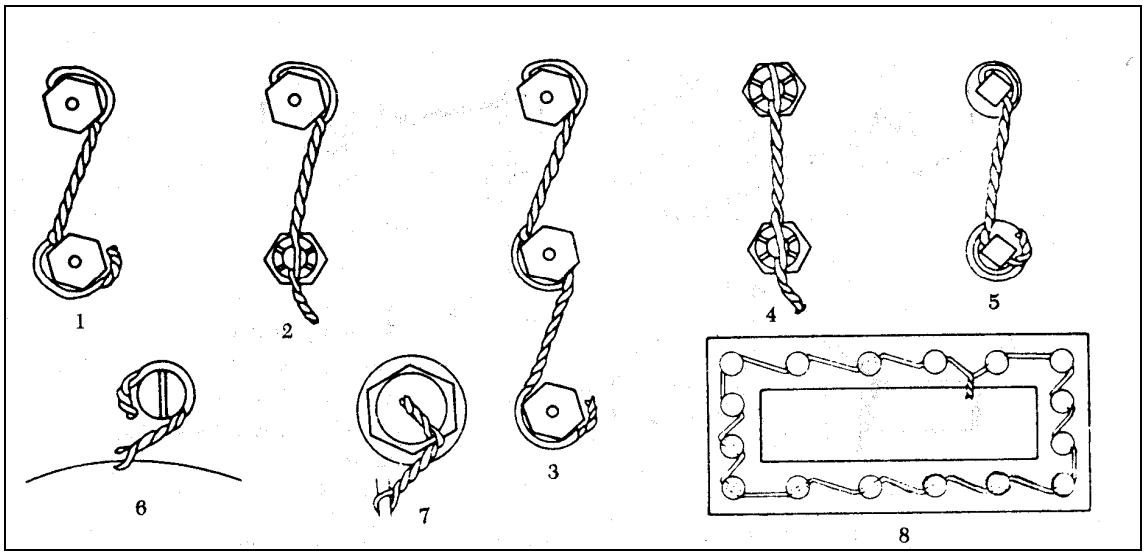
Lock wiring consists of running a twisted strand of wire from the component that we wish to secure to a fixed point. The wire is run in such a manner so that if the fastener attempts to turn loose it will be pulling against the tightly strung lockwire.



If a series of closely spaced components are to be lock wired a single strand of wire may be used if specified by the manufacturer. Any number of closely spaced components may be lock wired together however the maximum length of a single piece of lock wire shall not exceed twenty-four (24) inches.

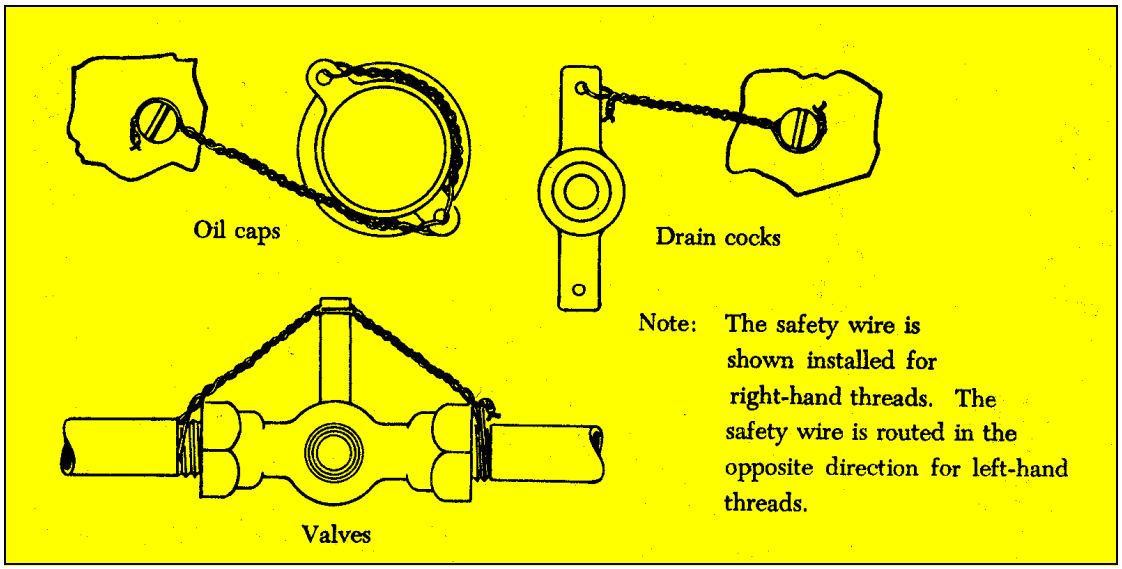
Unless specified by the manufacturer the lock wire span or run shall be no longer then six (6) inches. The wire shall be tightly twisted and it shall not be allowed to become nicked, kinked or otherwise damaged. Lock wire shall not be reused.

SAFETY/LOCK WIRING EXAMPLES?



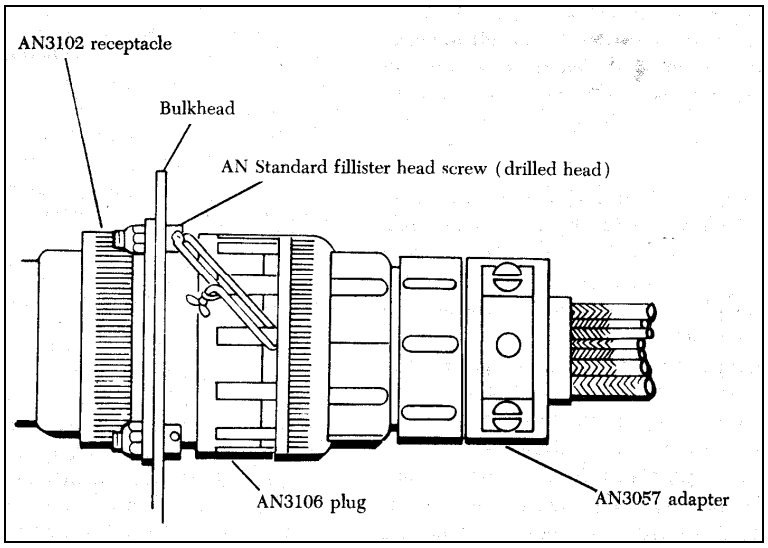
In each example the wire has been run through a hole in the fastener and then twisted around the fastener head so as to pull it tight. The twisted wire is then run to a fixed point. One fastener may be run to another but care must be taken to ensure that each fastener is preventing each other fasten from loosening. In all cases the specific manufacturers instructions should be followed.

Ensure cut ends are bent to avoid injury.



As in the first example the wire is fed through a predrilled hole, twisted and then run in such a manner so as to prevent the part from loosening.
The manufacturers instructions should always be followed.

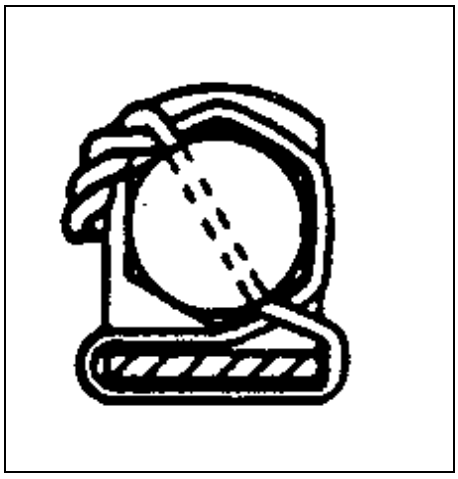
Ensure cut ends are bent over.

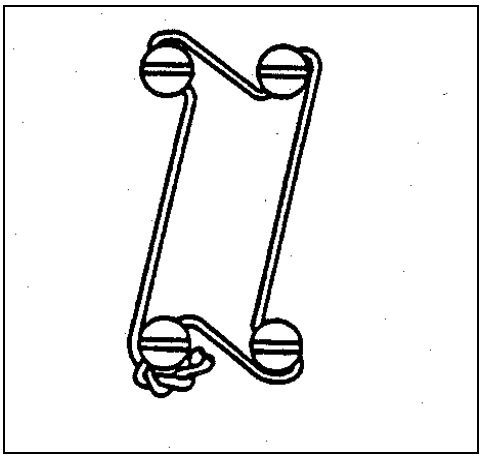


In this example the wire has been run through a predrilled hole on the collar of the plug, twisted and then fastened to a Fillister Head screw. Care must be taken to ensure that the wire is tight and is pulling the collar clockwise. Ensure all cut ends are bent over.

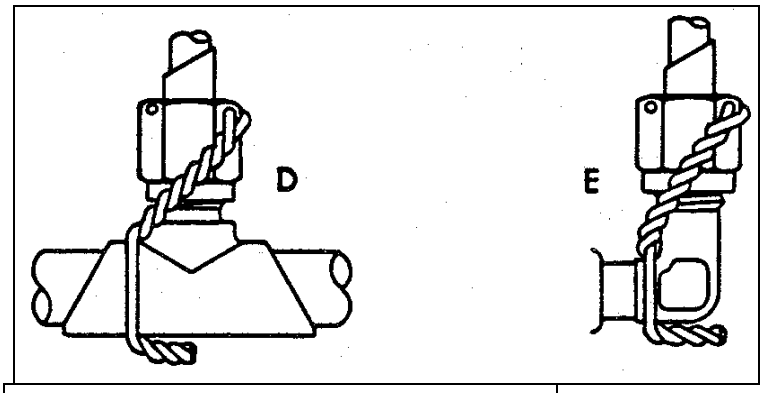
If a closely spaced group of identical components must be lock wired it is permissible to use a single strand if specified by the manufacturer.

Care must be taken to fold over the cut ends.

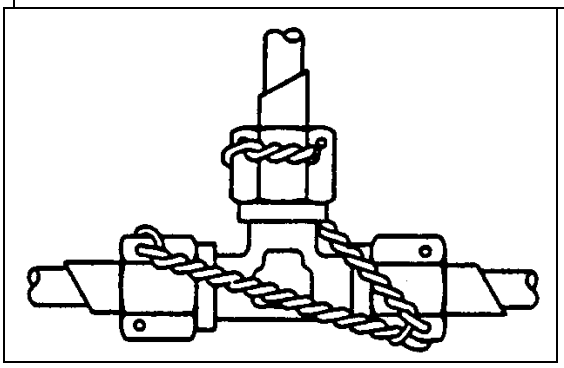




This example shows a bolt lock wired to an adjacent "L" bracket provided for lock wiring purposes. Notice how only a single strand is wrapped around the bracket. Care must be taken to fold over the cut ends

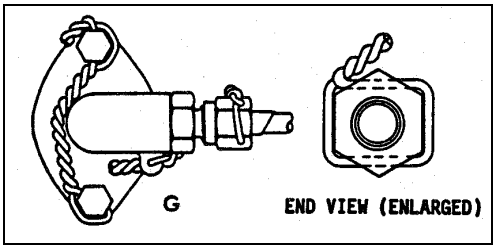


This example illustrates the correct manner to lock wire fittings when no lug or "L" bracket has been provided. Notice that the direction of wrap will pull the fitting tighter. All cut ends have been bent over.



In this example the three nuts on a "T" connector have been lock wired together. Notice how the wire always is run so as to pull the nuts tighter. All cut ends have been curled or bent over to avoid cuts.

Fittings that are made of very soft materials may be lock wired as shown to prevent the wire from tearing out. Again all cut ends are bent over.



CAUTION

In all cases the safety/lock wire must:

- ***pull the movable part so as to cause it to tighten.***
- ***be twisted unless the run is very short.***
- ***have cut ends curled or bent over to avoid cuts.***

Hardware and Fasteners

Hardware Classification: The organizations involved with the testing and standardization of hardware for the aerospace industry are:

AMS - Aeronautical Material Specifications
AN - AirForce-Navy
AS - Aeronautical Standard
ASA - American Standards Association,
ASTM - American Society for Testing and Materials
MS - Military Standard
NAF - Naval Aircraft Factory
NAS - National Aerospace Standard
SAE - Society of Automotive Engineers

Each organization has designed, tested certified specific pieces of hardware. When an engine is being designed the designer may select these standardized pieces of hardware. He will do this knowing that their eventual certification is assured as long as they are used for the purposes for which they were designed. It is vital when performing maintenance to ensure that hardware is only replaced with equivalent hardware.

Standard Hardware allows components to be efficiently and cheaply mass produced. Rather then having to design and certify each piece of hardware the manufacturer can select pre-approved and certified hardware "off the shelf". Since the manufacturer does not have to design, test and certify parts a significant cost saving is achieved. Standardized hardware also ensures that tools are guaranteed to fit. Any 1½" wrench will fit any 1½" bolt and any Dzus fastener will work with any other Dzus fastener. (Zie Google!)

Special Hardware is used if requirements exist that are not met by standardized hardware specifications.

CAUTION

USE SPECIAL OR MANUFACTURERS TOOLS WHEN SPECIFIED.
DO NOT ATTEMPT TO "MAKE DO" OR TO IMPROVISE.

Hardware Types

Aircraft hardware may be divided into the following groups:

- **Solid Shank Rivets**:
- **Special Rivets and fasteners**: *Pop, Self-Plug Friction Lock, Self-Plug Mechanical Lock, High Strength Pin Rivet, Threaded Rivets - Rivnuts*
- **Threaded Fasteners**: *Standard Aircraft Bolts, Nuts, Screws*
- **Pins**: *Rollpin, Clevis Pin, Cotter Pin, Taper Pin*
- **Washers** *Plain, Lock, Special*

- **Hole Repair Hardware**: *Heli-Coil, Acres Sleeves*
- **Cowling Fasteners**: *Dzus, AirLock, CamLock*
- **Control Cables**: *Steel Cable, Cable Terminators, Turn Buckles*

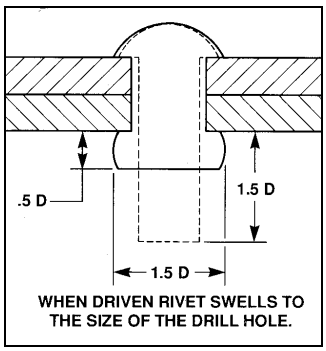
Each hardware group will be discussed in the following sections.

Advies:

Gebruik de CD ROM Mechanic''s Toolbox, bijna alle genoemde items worden behandeld.

1. Solid Shank Rivets:

Rivets are the most commonly used aircraft fastener. Unlike other fasteners rivets go through a physical size change when installed or "driven", see figure 34.



As the rivet is driven the cross sectional area will increase. The bearing and shear strength will also increase as the metal is "worked".

Figure 34 Solid Shank Rivet

Solid shank rivets are available in a number of standardized sizes. These rivets may be installed by hand or by a pneumatic gun. Notice that to install these rivets you will require access to both sides of the material. To remove a rivet the following procedure is used: (a) drill through rivet using a drill slightly smaller then the rivet diameter;
(b) knock off the rivet head using a chisel; then
(c) using a drift punch knock out the remainder of the rivet shank.

Rivets are usually made from aluminum or one of its many alloys. The construction material is identified by a letter designator in the rivet specification and by a mark on the rivet head. Some common rivet materials are listed below:

1100 Aluminum (A) - no identification mark, not for structural use, shear strength increases after installation.

2117 Aluminum Alloy (AD) - dimple on head, most widely used in modern aircraft.

2017 Aluminum Alloy (D) - raised teat on head, kept frozen until just prior to use, used for structural applications, high shear strength.

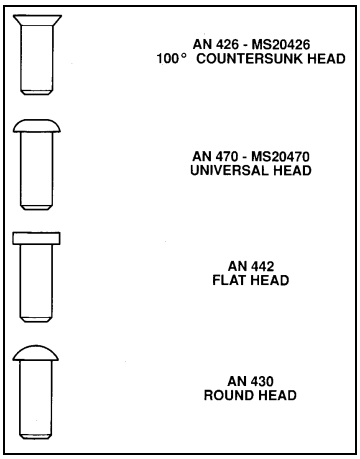
2024 Aluminum Alloy (DD) - 2 raised dashes on head, kept frozen until just prior to use, for structural applications.

7050T73 Aluminum Alloy (E) - raised circle on head, alloyed with Zinc.

5056 Aluminum Alloy (B) - raised cross on head, used for Magnesium

Corrosion-resistant Steel (F) - no marking on head, to rivet corrosion resistant steel.
Monel (M) - 2 recessed dimples, replaces corrosion-resistant steel rivets, low strength.

Solid shank rivets are available in both countersunk and protruding head designs, see figure 35.



The countersunk heads will allow the rivet to be flush mounted to increase aerodynamic efficiency and to lessen drag. The surrounding metal may have to be countersunk or dimpled in order to install countersunk head rivets.

Countersunk rivets are normally installed in such a manner that .005 - .007" of the head protrudes. This will ensure that the rivet head is in full contact with the rivet set. Once the rivet has been driven the protruding portion of the head is shaved off.

Figure 35 Rivet Head Types

Rivets are coded to indicate their head style, material and size as shown in figure 36. The rivet dimensions used in the coding system are measured as shown in figure 37.

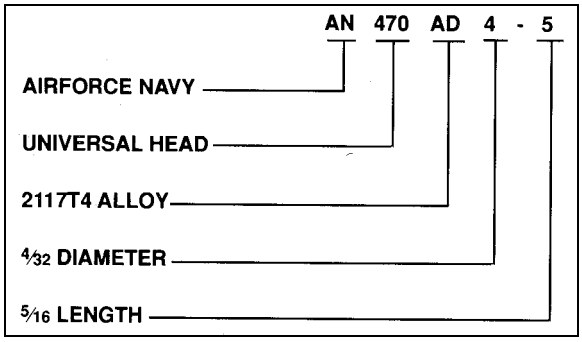


Figure 36 Rivet Identification

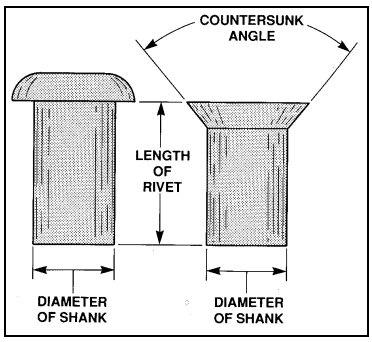
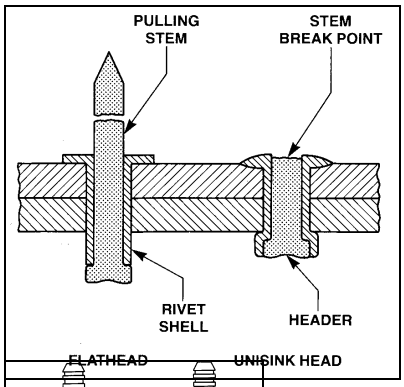


Figure 37 Rivet Measurements

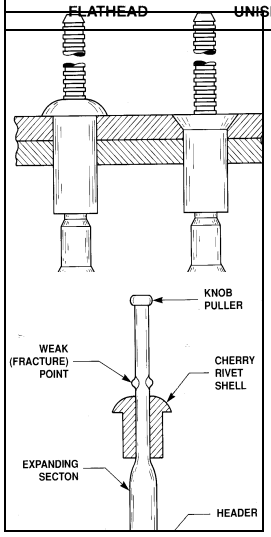
2. Special Rivets and Fasteners

Unlike conventional rivets, special rivets may be installed from only one side of the material. This simplifies assembly and saves time during repair and construction. Several types of special rivets known as "blind" rivets are discussed below:



Pop Rivets - are used for temporary line up of parts during complex assembly processes. They are not used for commercial aircraft structural components. The rivet is installed from one side of the work, a special puller is placed over it, the puller pulls the stem which expands the header and then breaks the stem off. Pop rivets are available in both flat and modified flush heads. These rivets are usually made from soft aluminum alloy, steel, copper or Monel. See figure 38 for a typical Pop rivet shown both before and after the installation process.

Figure 38 Pop Rivet



Self-plugging, Friction Lock Rivets - or "Cherry" rivets are used for both general and structural repairs to light aircraft. The rivet is known as a self-plugging because the rivet stem will stay in place after the rivet has been installed. Two head styles are available: a universal and a 100^0 countersunk head. The rivet is comprised of a shell and a pulling stem or mandrel. The mandrel has a knob on one end to facilitate pulling, a weak point, an expanding section to form the head on the blind side of the work and a header for forming the bucktail on the end of the mandrel. Once the rivet has been installed a small portion of the broken mandrel will protrude. This must be filed off and shaped. The great strength of these rivets is due to the fact that both the rivet shell and the stem are left installed in the work.

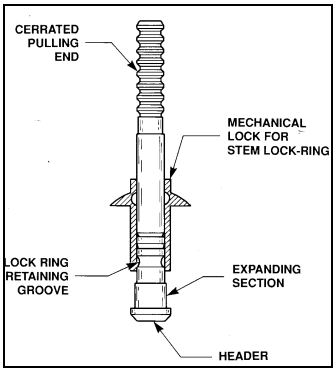
Figure 39 "Cherry" Friction Lock Rivet

CAUTION

IF A FRICTION LOCK IS USED IN LIEU OF A SOLID SHANK RIVET THE DIAMETER MUST BE INCREASED AT LEAST 1/32" TO COMPENSATE FOR THE LOSS OF STRENGTH IF THE RIVET STEM SHOULD FALL OUT.

Self-plugging Mechanical-lock Rivets - are designed so that the center stem will not fall out due to vibration and weaken the rivet. The four main types of self plugging mechanical lock rivets are Huck-Loks, CherryLOCKs®, Olympic-loks and CherryMAX®. These four types are discussed below.

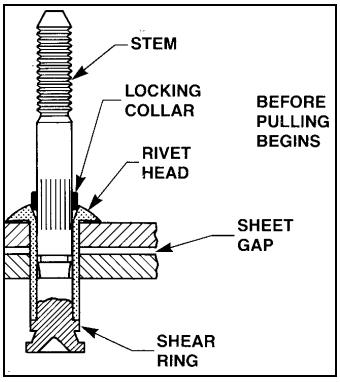
1.



Huck-Loks are a type of mechanical lock rivet that may be used as an in lieu replacement, with no diameter increase, for solid shank rivets. Due to the complex tools required for installation their use is usually restricted to depot and factory maintenance facilities. Huck-Loks are available in several sizes and combinations of alloys. See figure 40 for a typical Huck-Lok rivet.

Figure 40 Huck-Lok Rivet

2.



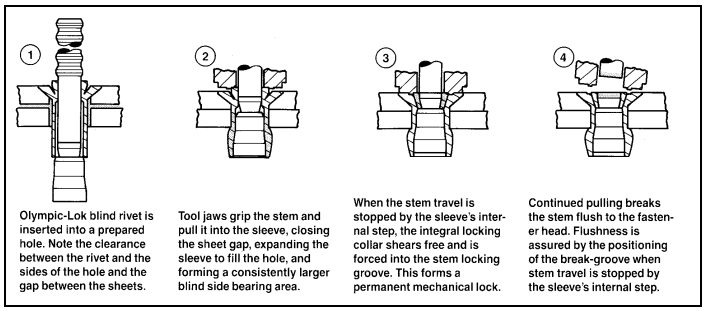
CherryLOCKs® - are a type of mechanical lock rivet that may be used as an in lieu replacement, with no diameter increase, for solid shank rivets. Due to the complex tools required for installation their use is usually restricted to depot and factory maintenance facilities. CherryLOCKs® are available with both universal and 100^0 countersunk heads and in several sizes and combinations of alloys. See figure 41 for a CherryLOCKs® rivet.

Figure 41 CherryLOCKs®

CAUTION

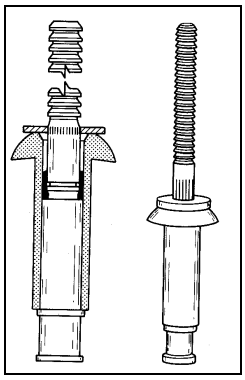
FAILURE TO USE THE CORRECT LENGTH OF CherryLOCK® RIVET WILL PRODUCE AN INSTALLATION THAT APPEARS CORRECT BUT WILL ACTUALLY BE VERY WEAK. USE A RIVET SELECTION GAUGE TO DETERMINE LENGTH.

3.



Olympic-loks - are a light weight,, mechanical locking, spindle type, blind rivet. These rivets are available in universal, 100^0 flush and 100^0 flush shear head styles as well as various sizes and materials. Olympic-loks are the most inexpensive self-plugging mechanical-lock rivets.
Figure 42 Olympic-loc Rivet

4.



CherryMAX® - rivets are both economical and strong. Only a single sized installation tool is required to install all sizes of CherryMAX® rivets. The rivet is available in both universal and countersunk head styles and in various alloy compositions. See figure 43 for a typical Cherry MAX® rivet.

Figure 43 CherryMAX® Rivet

High Strength Pin Rivets - are designed to be extremely strong and lightweight. These fasteners are used in place of conventional AN nuts and bolts since they do not stretch during installation and initial torquing. Stretching causes the diameter of the bolt to decrease and may lead to eventual component looseness. These fasteners are installed in a pre-drilled hole using an interference fit. To ensure that the correct length of pin rivet is used a Length Gauge is used to determine rivet size, see figure 44.

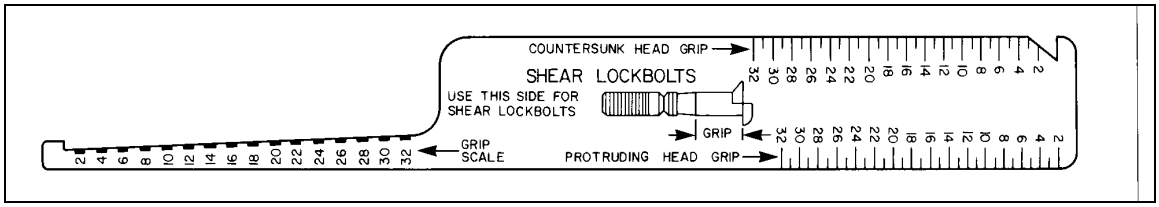
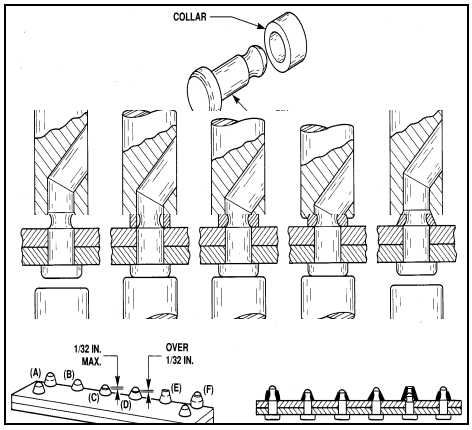


Figure 44 Lockbolt Thickness/Length Gauge

The seven most common types of high strength pin rivets will be discussed in the following sections.

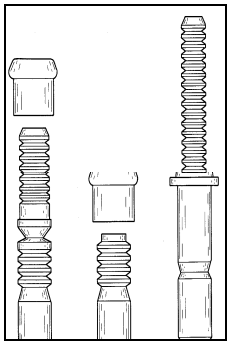
1.



Hi-Shear rivets - are extremely strong, non-blind (access to both sides) fasteners commonly used in high stress areas. Theses rivets have the same strength characteristics as a conventional AN bolt and nut. The rivets are available in both flat and countersunk head styles and are made from the same alloy as a high tensile AN bolt. See figure 45 for sample Hi-Shear rivet and installations.

Figure 45 Hi-Shear Rivet

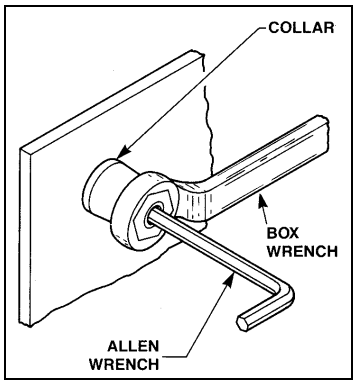
2.



Lockbolts - are made according to military (MS) specifications for use in very high stress areas. Lockbolts are available in both SHEAR and TENSION versions. The three styles of lockbolt; pull, stump and blind are illustrated in figure 46.

Figure 46 Lockbolts

3.



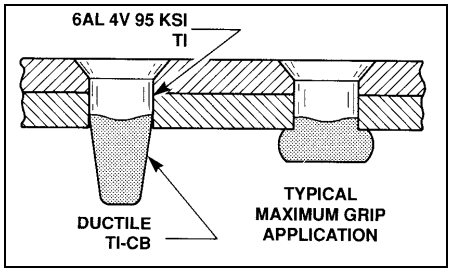
Hi-Loks - are used to withstand both bearing and shear loads in high-stress areas. They are made from titanium, stainless steel and aluminum. They are available in both flat and countersunk heads in a variety of sizes. The threads used on a Hi-Lok are compatible with AN style nuts. An Allen Key and Box-end wrench are required for Hi-Lok installation. See figure 47 for Hi-Lok installation.

Figure 47 Hi-Lok Installation

4.

Hi-Lites - are a derivative of the Hi-Lok pin rivet previously discussed. The Hi-Lite is lighter and shorter but retains the strength of the Hi-Lok.

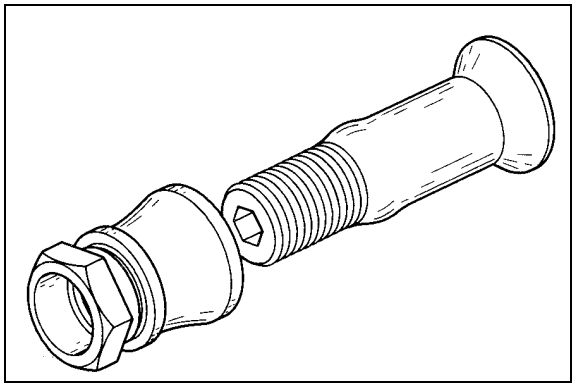
5.



CherryBucks - are a one piece titanium alloy fastener. Since the fasten is composed of only one piece it is ideal for installation in FOD sensitive areas (GTE intakes). See figure 48 for a typical CherryBuck installation.

Figure 48 CherryBuck Installation

6.

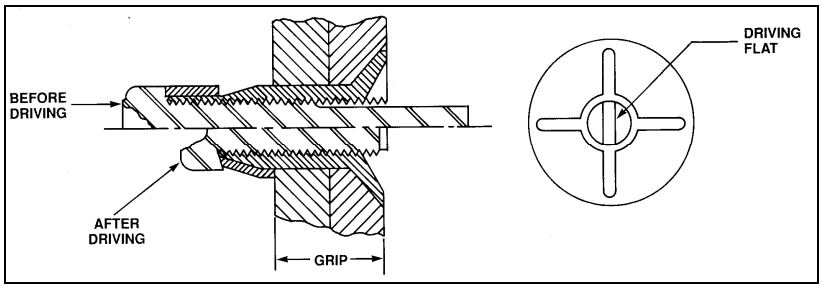


Taper-Loks and Hi-Tigue bolts - are the strongest form of special fasteners. TheTaper-Lok has a slight taper and is installed in a conical type hole. As the washernut is tightened the fastener expands and presses into the sides of the conical shaped hole thereby locking itself into place. The Hi-Tigue bolts is tapered and incorporates a ball shaped bump on its shank, see figure 49.

Figure 49 Hi-Tigue Bolt

The ball will preload the hole before the shank begins to expand and lock itself into place. Since the material around the hole is under a preload it does not become cold worked and liable to eventual failure. Hi-Tigue fasteners are installed using an Allen and Box-end Wrench.

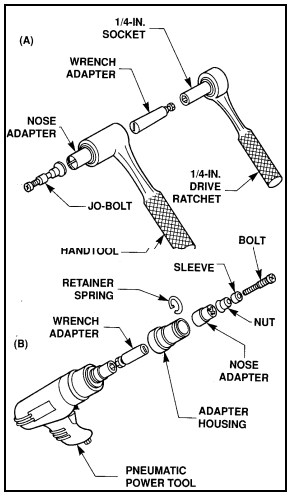
7. Figure 50 Jo-Bolt Installation



Jo-Bolts - are high strength structural fasteners commonly used where sufficient clearance is no t available for An, MS or NAS nuts and bolts. To install a Jo-Bolt the

hole is drilled, reamed and then countersunk. The Jo-Bolt is then inserted and held by the installation tool. The wrench adapter is then used to screw the bolt up through the nut. This forces the sleeve over the tapered outside of the nut forming the blind head. When the driving is complete the driving flat of the bolt will break off, see figure 50.

A special hand or pneumatic tool is required to install Jo-Bolts, see figure 51



(A) Hand operated installation tool.

(B) Pneumatic operated installation tool.

Figure 51 Installation Tool

3. Threaded Fasteners

Threaded fasteners such as nuts and bolts allow parts to be securely assembled and easily disassembled for repair and inspection. Most threaded fasteners will be designed to AN, NAS or MS specifications. Fasteners are produced using American National Coarse (NC), American National Fine (NF) or American Standard Unified Fine (UNF) thread designs. Bolts may be designated by their head design, diameter and/or number of threads per inch (pitch). Also, the threads may be designated as Class A (loose fit), Class B (free fit), Class C (medium fit) or Class 4 (close fit). Most aircraft bolts are Class 3 with the exception of wing-nuts which are usually Class 4.

CAUTION

STANDARD FASTENERS HAVE AN AN, NAS OR MS SPECIFICATION NUMBER AND A PART NUMBER.
SPECIAL FASTENERS WILL ONLY HAVE A PART NUMBER.
EVEN THOUGH THEY APPEAR IDENTICAL STANDARD AND SPECIAL FASTENERS ARE NOT "IN LIEU" ITEMS.

The heads of aircraft bolts are marked to indicate composition and, in some cases, the manufacturer. See figure 52 for typical head markings.

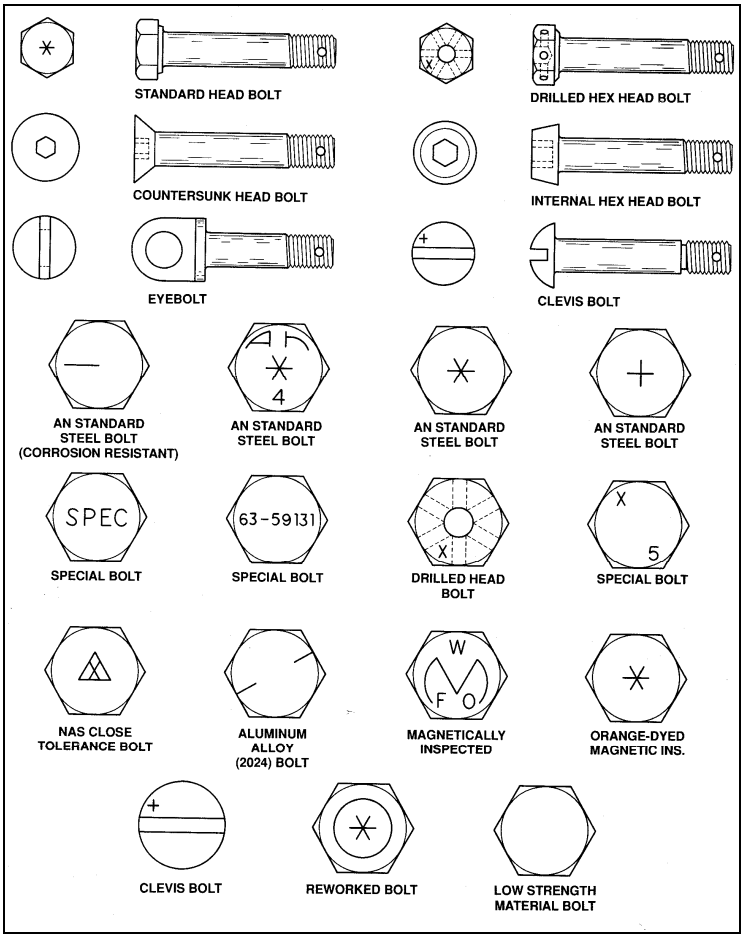
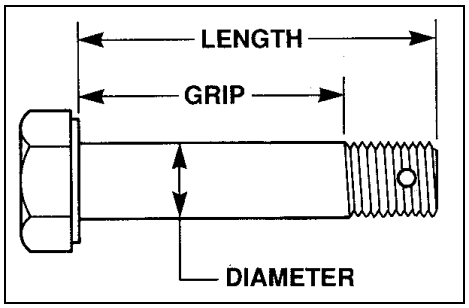


Figure 52 Typical Bolt Head Markings

Standard Aircraft Bolts

The most commonly used bolts for aircraft use are discussed below.

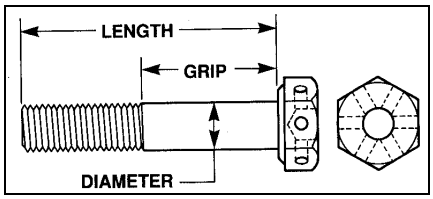
1.



Airframe Bolts - are used for aircraft structural applications. The common AN3 to AN20 Airframe bolts are illustrated in figure 53. These bolts are available in cadmium plated nickel steel, corrosion resistant steel and in 2024 aluminum alloy. These bolts have National Fine Threads with a Class 3 fit.

Figure 53 AN3 to AN20 Airframe Bolt

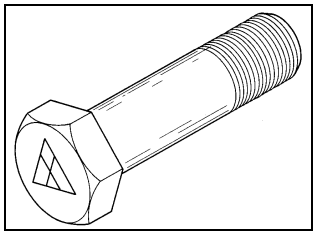
2.



Drilled-head Engine Bolts - have a small hole drilled through each of the head flats to facilitate safety wiring. The common AN73 and AN81 bolts are shown in figure 54.

Figure 54 Drilled-head Engine Bolts

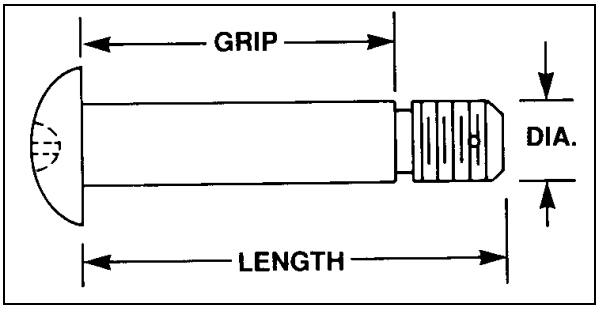
3.



Close-tolerance Bolts are used where a bolt is subjected to a pounding type stress or where the final structure is comprised of both riveted and bolted members. The An173 to An186 Close-tolerance Bolts are shown in figure 55.

Figure 55 Close-tolerance Bolt

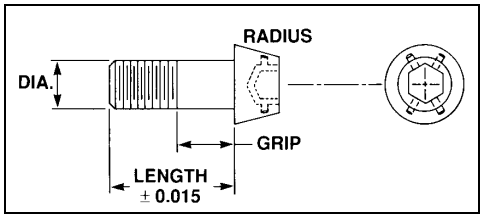
4.



Clevis Bolts - are used when the assembly will encounter shear stress, only. They are commonly used to attach control cables to control horns. The smooth portion of the shank will allow the bolt to pivot while the threaded portion prevents the bolt from falling out. Both self-locking and cotter pin type nuts may be used with a Clevis bolt. See figure 56 for an example of a Clevis bolt.

Figure 56 Clevis Bolt

5.



Internal Wrenching Bolts - are used primarily for tensile loads. They are installed using an Allen Wrench and they require a countersunk hole. See figure 57 for a typical Internal Wrenching Bolt.

Figure 57 Internal Wrenching Bolt

CAUTION

INTERNAL WRENCHING BOLTS ARE STRONGER THEN THE "IDENTICAL" AN SERIES BOLTS.
FOR THIS REASON AN SERIES MUST NEVER BE SUBSTITUTED FOR MS SERIES BOLTS.

CAUTION

TO PREVENT LOOSE BOLTS FROM FALLING OUT AND BECOMING A FOD HAZARD THEY SHOULD SHOULD BE INSTALLED POINTING INBOARD, DOWN AND/OR AFT UNLESS OTHERWISE SPECIFIED BY THE MANUFACTURER.

Standard Aircraft Nuts

Nuts are used to hold threaded fastens secure. In order to keep the nut tight despite vibration, load and temperature swings a cotter pin, insert or spring type lock washer may be used. Nuts are divided into three primary types; non-Self-locking nuts, self-locking nuts and Tinnerman Nuts. Each of these types and their derivatives are discussed below.

1. Non Self-locking Nuts - will require a locking device such as a lock wire, cotter pin or lock washer to maintain their tightness. The following section will discuss the most common Non Self-locking Nuts.

The **AN310 Aircraft Castle Nut** - is a fine thread nut designed to be used on bolts subject to both shear and tensile loads. This nut is available in cadmium plated nickel steel, corrosion resistant steel and in 1024 aluminum alloy. See figure 58 for an example.

The **AN320 Aircraft Shear Castle Nut** - is similar to the AN310 but it is only used where subject to shear loads on Clevis bolts. See figure 58 for an example.

The **AN315 Aircraft Plain Nut** - have no provisions for locking or wiring to the bolt. These nuts must always be used with a jam nut or lock washer. See figure 58 for an example.

The **AN316 Check Nut** is designed to be used as a jam nut to lock a nut to the bolt. See figure 58 for an example.

The **AN340 Coarse-thread Machine Screw Nut** is designed for general purpose aircraft use. See figure 58 for an example.

The **AN345 Fine-thread Machine Screw Nut** is designed for general purpose aircraft use. See figure 58 for an example.

The **AN355 Slotted Engine Nut** is for engine use only. See figure 58 for an example.

CAUTION

THE AN355 SLOTTED ENGINE NUT IS NOT FOR AIRFRAME USE.
THIS NUT IS DESIGNED FOR ENGINE USE ONLY.
IF IN DOUBT, CONSULT THE APPROPRIATE SERVICE MANUAL.

The **AN360 Plain Engine Nut** - is similar to the AN355 but it has no slots to allow the use of a cotter pin. This nut is for engine use, only. See figure for 58 for an example.

CAUTION

THE AN360 PLAIN ENGINE NUT IS NOT FOR AIRFRAME USE.
THIS NUT IS DESIGNED FOR ENGINE USE ONLY.
IF IN DOUBT, CONSULT THE APPROPRIATE SERVICE MANUAL.

The **AN350 Wing Nut** - is a nut that is designed to be removed without tools by hand. See figure for 58 for an example.

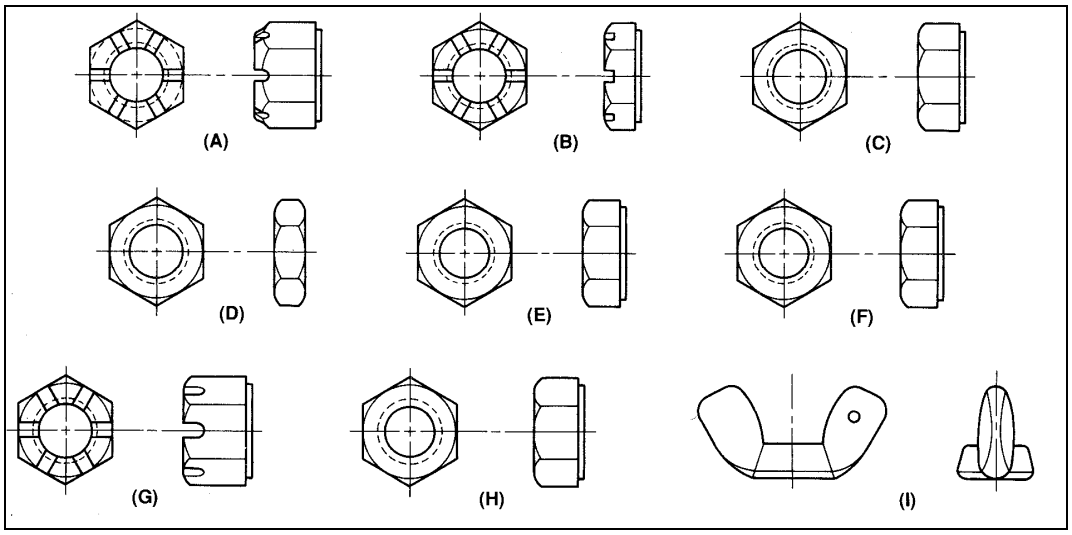
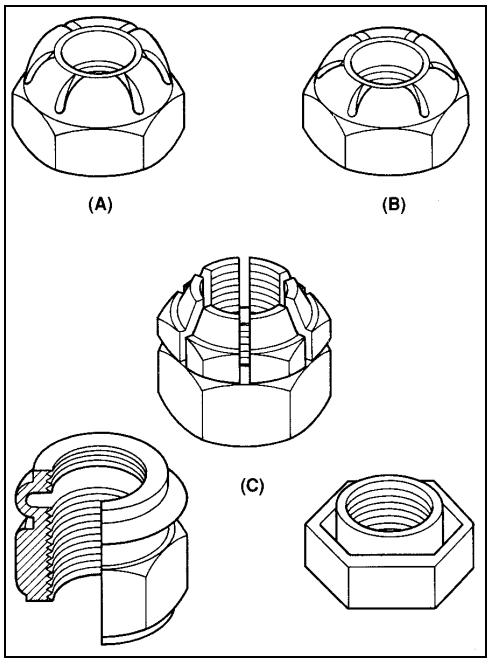


Figure 58 Non Self-locking Nuts

(A) AN310 castle nut
(B) AN320 shear castle nut
(C) AN315 plain nut
(D) AN316 check nut
(E) AN340 mach. screw crse
(F) AN345 mach. screw fine
(G) AN355 slotted engine nut
(H) AN360 plain engine nut
(I) AN350 wing nut

2. Self-locking Nuts - will incorporate a built in locking device to prevent them from working loose due to load, temperature or vibration fluctuations. The following section will discuss Low Temperature and High Temperature self-locking nuts.

Low Temperature Self-locking Nuts contain an elastic insert located just above the threads. The hole through the elastic insert is slightly smaller then the diameter of the bolt. The bolt may be turned on by hand until it reaches the insert, at that point a wrench will be required. Since the insert is elastic the bolt does not actually "cut" threads into it. Therefore the nuts and inserts may be safely reused as long as they appear in a serviceable condition. These nuts may be used as long as the temperature does not exceed 250^0 F. Care must be taken to ensure that at least 1 thread of the bolt is above the elastic insert. Care must also be taken to ensure that the bolt does not "bottom-out" before the insert has a grasp on the threads. See figure 59a & b for an example.



(A) AN365 (MS20365) ***low temperature*** *self-locking nut*

(B) AN364 (MS20364) ***low temperature*** *shear self-locking nut*

(C) AN363 ***high temperature*** *self-locking nuts*

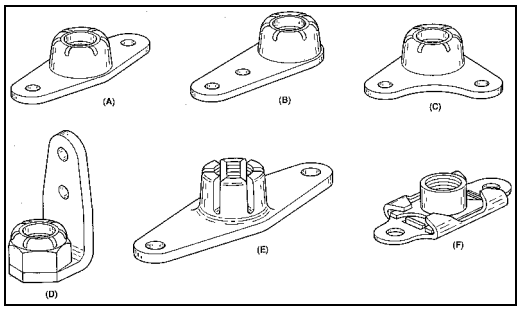
Figure 59 Self-locking Low/High Temperature Nuts

High Temperature Self-locking Nuts do not use an elastic insert. Usually the ends of the nut are slotted and then swaged together or the end of the nut is made into an oval shape. In either case the nut will tightly grip the bolt despite load, temperature or vibration cycles. In most cases these self-locking nuts are not reusable. See figure 59c for an example.

3. Special Forms of Self-locking Nuts - designed for specific uses and situations. Several special self-locking nuts are discussed below.

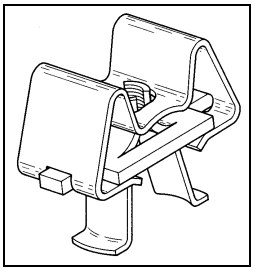
The **AN364 Shear Self-locking nut** is similar but thinner then the AN365. It is designed to be used when only shear loads will be encountered. It is used on clevis bolts that have not been drilled for a cotter pin or safety wire. See figure 60 for AN365 example.

The **Anchor Nut or Plate Nut** is permanently mounted to the aircraft structure. Inspection plates and access doors are mounted by simply screwing them to the anchor nuts. The nuts may be mounted rigidly or in such a manner that they are free to move slightly (floating). See figure 60 for typical examples.



(A) AN366F 2 lug anchor nut
(B) NAS1025 1 lug anchor nut
(C) NAS1027 corner anchor nut
(D) AN256F right angle anchor nut
(E) AN362F high temp. 2 lug anchor nut
(F) 2 lug floating anchor nut

Figure 60 Anchor or Plate Nuts



The **Tinnerman Instrument Mounting Nut** consists of a nonmagnetic, phosphor bronze cage containing a brass nut. The Tinnerman nut is used to mount instruments and controls in an instrument panel. See figure 61 for an example.

Figure 61 Tinnerman Nut

The **Anchor-type Tinnerman Nut** is used as a cost effective alternate to anchor nuts to secure panels on light aircraft. See figure 62. Light aircraft cowls are also mounted using **U-type Tinnerman Nuts** to minimize costs. See figure 63.

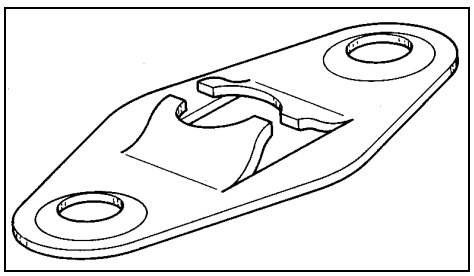


Figure 62 Anchor Type Tinnerman Nut

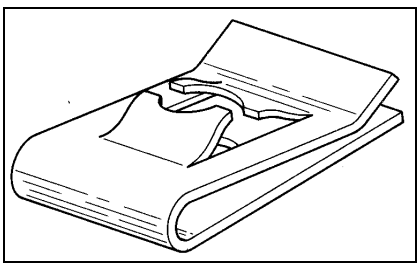


Figure 63 U-Type Tinnerman Nut

Standard Aircraft Screws

The three common screw types used on aircraft are the machine screw, structural screws and self-tapping screws. These will be discussed in the following section.

1. **Machine Screws** are used for attaching failings, inspection plates, line clamps and other light, non-structural parts. Machine screws are threaded for the full length of their shank and are normally used as a Class 2 fit. The most common machine screws are discussed in the following eight sections and illustrated in figure 64.

AN500 Coarse-thread Fillister-head - slotted, drilled, fillister screw, Class 3 thread.

AN501 Fine thread Fillister-head - similar to AN500 with fine thread.

AN505 Coarse thread 82^0 Flat-head - recessed head, countersunk, replace by MS35190.

AN510 Fine thread 82^0 Flat-head - similar to AN505 with fine thread.

AN515 Coarse-thread Round-head - replaced by MS35206, slotted or recessed head, cadmium plated carbon steel, brass is AN515R-B.

AN520 Fine-thread Round-head - similar to AN515, fine thread, AN520R-B is brass replaced by MS35215.

AN526 Truss-head Fine-thread - large head, slotted and recessed head.

AN507 100^0 Flat-head - replaced by MS24693. MS24693S is cadmium plated carbon steel and MS24693BB is black oxide coated brass, coarse and fine threads.

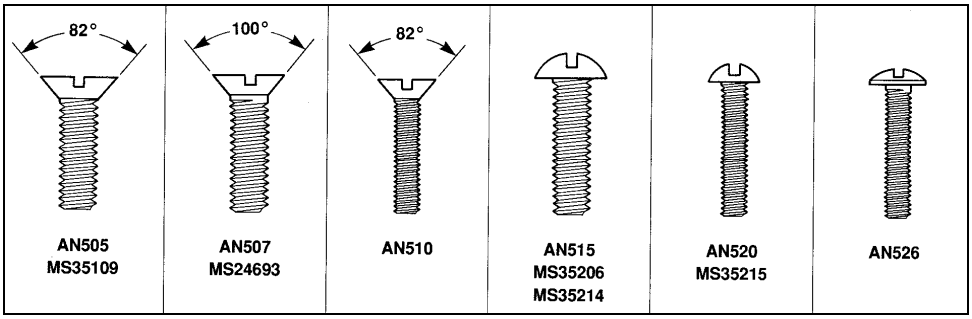


Figure 64 Common Aircraft Machine Screws

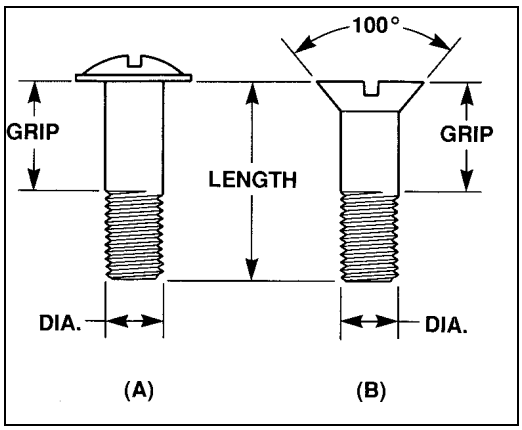
2. **Structural Screws** are used for fastening structural components directly to the airframe. The most common structural screws are discussed in the following sections and illustrated in figure 65.

AN502 Fine-thread Fillister-head Screw - similar to AN500 but high strength steel.

AN503 Coarse-thread Fillister-head Screw - similar to AN501 but high strength steel.

AN509 100^0 Flat-head Screw - replaced by MS24694, heat treated carbon steel and cadmium plating,

AN525 Washer-head Screw - large head and washer, cadmium plated high strength steel.



(A) AN525 washer head

(B) AN509 (MS24694) 100^0 countersunk head

Figure 65 Aircraft Structural Screws

3. **Self-tapping Screws** are used for fastening thin sheets of metal, plastic or plywood. These screws have a relatively coarse thread which ends in a pointed tip (Type A) or in a blunt tip (Type B). The four common head styles are round head, truss head, countersunk head and countersunk oval screw. Two common types of self tapping screws are described below and illustrated in figure 66.

AN530 - round head, self tapping screw with Type B end.

AN531 - countersunk, flathead, self-tapping screw with Type B end.

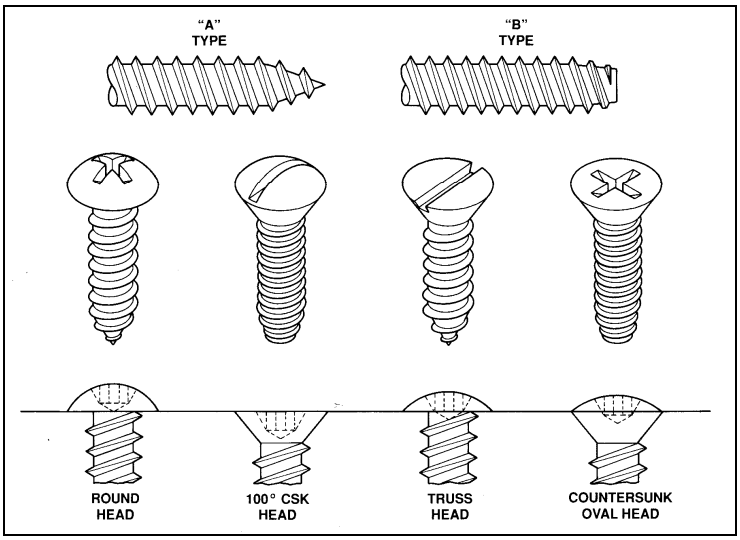


Figure 66 Self-tapping Screws

4. Aircraft Pins

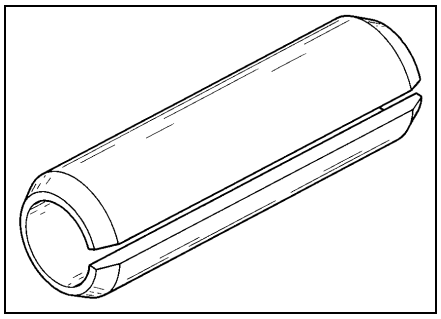


Figure 67 Aircraft Rollpin

Rollpins are used to allow a joint to move around an axis in a controlled manner. Rollpins are made of flat spring steel that has been rolled into a cylinder. Once pressed into the hole spring tension will keep the pin in place. To remove a rollpin it is simply tapped out with the appropriate size punch. See figure 67 for an illustration of an aircraft rollpin.

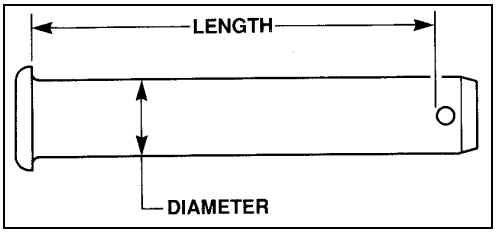


Figure 68 Aircraft Clevis Pin

Clevis or Flat Head Pins are used as hinge pins in aircraft control systems. They are made of cadmium plated steel and are held in place by a washer and cotter pin. Care must be taken to install these pins with the head up. See figure 68 for an illustration.

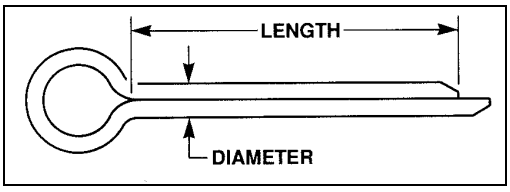


Figure 69 Aircraft Cotter Pin

Cotter Pins are used to hold castellated nuts and clevis pins in position. Cotter pins are made of cadmium plated steel or corrosion resistant steel alloy. The pin is installed by placing it through a drilled hole and then spreading the two legs. Care must be taken to curl or bend the legs so that they do not protrude. See figure 69 for an example.

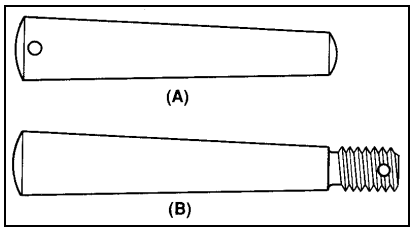


Figure 70 Aircraft Taper Pin

Taper Pins are used to make tight joints on shafts. They are designed to carry shear loads, only. The AN386 taper pin is similar to AN385 except that the smaller end has been drilled to accept a self-locking shear nut or a shear castle nut. See figure 70.

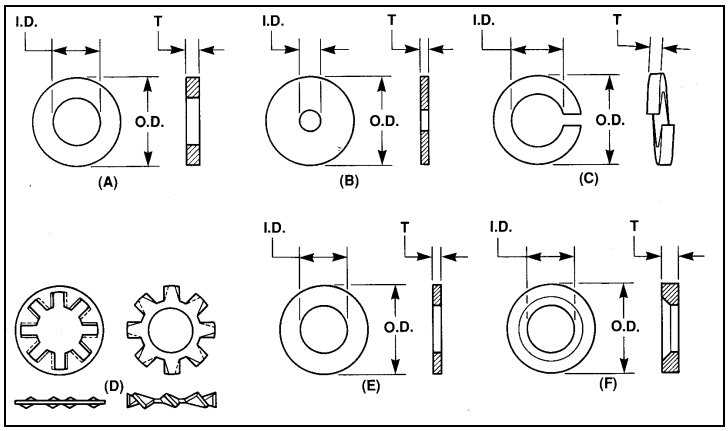
5. Aircraft Washers

Washers are used to provide a load bearing surface for nuts, to act as shims and to apply tension between a nut and the material to prevent the nut from vibrating loose. The most common washers are discussed in the following section and illustrated in figure 71.

Plain Washers are used to provide a smooth, stable surface between a bolt head and the surface or nut. Washers are made from cadmium plated steel, brass, corrosion resistant steel or 2024 aluminum alloy. A thin series of washers (AN960) is often used to allow the castellations of a castellated nut to line up with a cotter pin hole. A large area series of washers (AN970) is used to avoid crushing when working with wood or composite structures. See figure 71 for illustrations.

Lock Washers are placed between the nut and the work surface to provide a spring tension on the nut and bolt threads. This will prevent the nut from vibrating loose. The AN935 split lock washer is split and given a slight twist to provide the spring tension. The AN936 lock washer uses a series of internal or external teeth which are slightly bent to provide the spring tension. See figure 71.

Special Washers have been designed to fill specific requirements. One example is the MS20002 flat washer used under the heads of high-strength internal wrenching bolts. see figure 71.

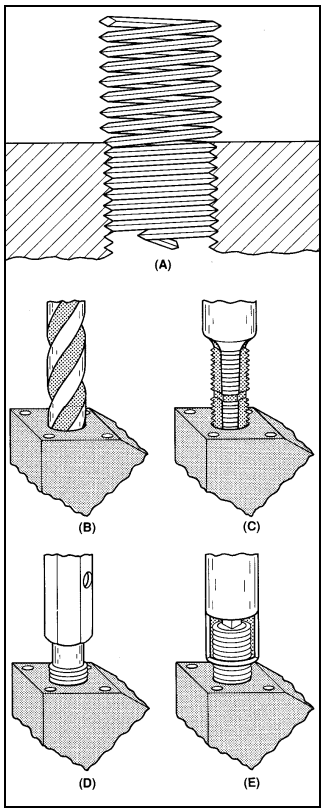


(A) AN960 plain washer
(B) AN970 large area washer
(C) AN935 split lock washer
(D) AN936 shakeproof lock washer
(E) MS20002 high strength plain washer
(F) MS20002 high strength countersunk washer

Figure 71 Aircraft Washers

6. Hole Repair Hardware

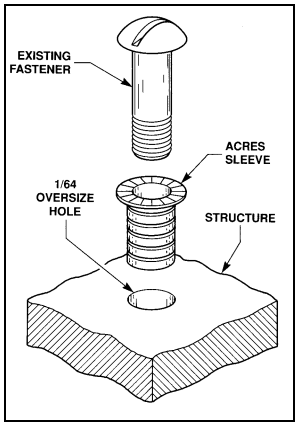
When screws and bolts are used in soft metal it may be necessary to protect or to repair the threads in the soft metal. This may be done by using Heli-Coil® inserts or Acres Sleeves. Both inserts and sleeves are discussed below.



Heli-Coil® inserts are stainless steel helixes which are used to protect or repair threads. To use the insert the hole with the worn or damaged threads is first tapped slightly oversize with a special Heli-Coil tap. The Heli-Coil insert is then driven into the hole with a Heli-Coil tool which causes the insert to wedge itself into the hole. Then the tang at the bottom of the insert is broken off to allow the bolt to pass completely through the insert. See figure 72 for a pictorial installation sequence.

(A) Heli-Coil insert
(B) drill out damaged threads
(C) cut new threads with special Heli-Coil tap
(D) Gauge new threads
(E) install insert and remove tang

Figure 72 Heli-Coil®



Acres Sleeves are used to repair holes that have become oversize. The hole is simple drilled out and the sleeve is installed. The sleeve may be held in place by friction or an adhesive may be used. Care must be taken to ensure that the material will not be weakened by the drilling. Refer to figure 73 for an illustration.

Figure 73 Acres Sleeve

7. Cowling Fasteners

Special fasteners are used on panels and cowlings that must frequently be removed. These fasteners must allow fast removal and installation and be very durable. The three types most commonly used are discussed below.

Dzus Fasteners consist of a hard strip of spring steel wire which is welded across a hole in the fixed portion of the cowling and a special stud located on the panel or cowling itself. In use the stud is rotated a quarter of a turn to either engage or disengage the wire. When the fastener is being tightened a distinct click will be heard as the wire is forced up the ramp in the stud and locks into place. See figure 74.

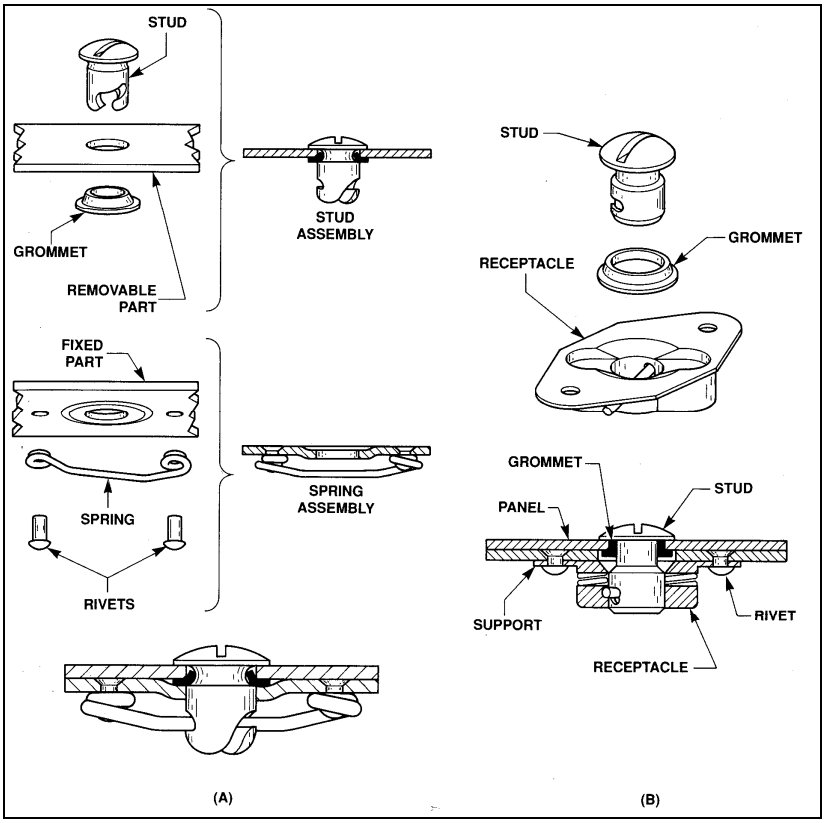
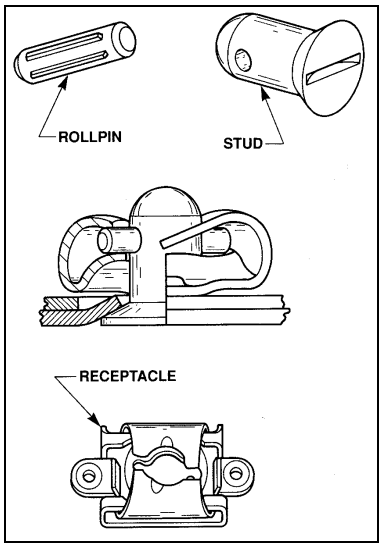
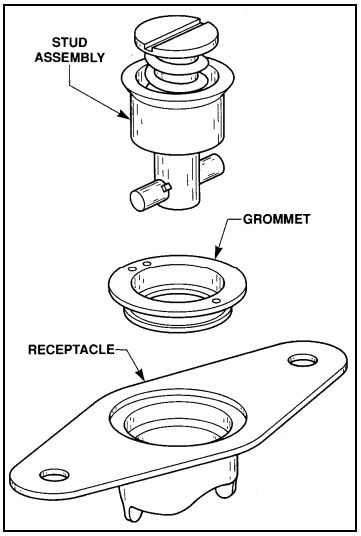


Figure 74 Dzus Fasteners



Airlock Fasteners consist of a steel stud and spring located on the removable piece and a spring steel receptacle on the airframe. The fastener is locked or unlocked by rotating it a quarter of a turn causing the pin to drop into an indent in the receptacle spring. See figure 75.

Figure 75 Airlock Fastener



Camlock Fasteners use a stud and a steel pin mounted to the removable part with a metal grommet. The stud fits into a pressed steel receptacle and is locked or removed with a quarter turn. See figure 76.

Figure 76 Camlock Fastener

8. Control Cables and Terminals

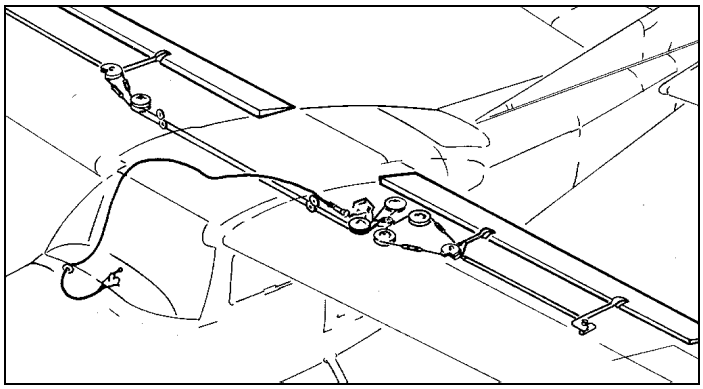
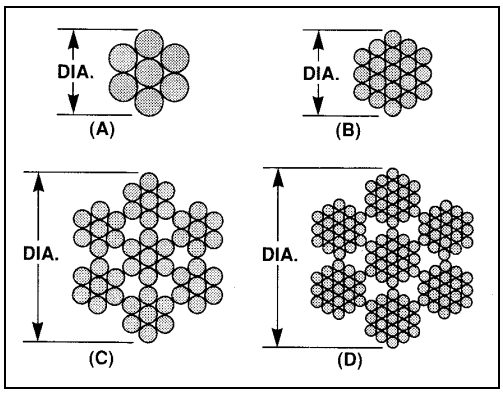


Figure 77 Steel cables are used in many aircraft to perform control functions. Cable is light, strong and its flexibility allows it to be routed through the complex airframe. One disadvantage however is that changes in temperature will cause the cable to lose tension and change the control "feel". In larger aircraft an automatic tensioning system is often used while in smaller aircraft the cables are adjusted to a compromise tension. Cables are available in several different configurations depending on the strength and flexibility that is required. A 1 X 7 configuration means that the cable consists of 7 individual wires while a 7 X 7 configuration means that the cable is comprised of 7 strands each containing 7 wires. See figure 78 for other examples. The most common cable types are discussed below.

Non-flexible cable is used in installations where pulleys are not required. This cable is available in either 1 X 7 or 1 X 19 configurations. The cable is made from galvanized carbon steel or stainless steel. See figure 78a & b.

Flexible Cable is a steel cable available in 7 X 7 configuration. Usually these cables are "performed" (each strand twisted) to ensure that the cable retains its shape when cut. Preforming also gives extra flexibility and relives bending stresses on the individual strands. See figure 78c.

Extra-Flexible Cable is a galvanized or stainless steel cable available in a 7 X 19 configuration. This cable is also performed. See figure 78d.



(A) 1 X 7 non-flexible cable

(B) 1 X 19 non-flexible cable

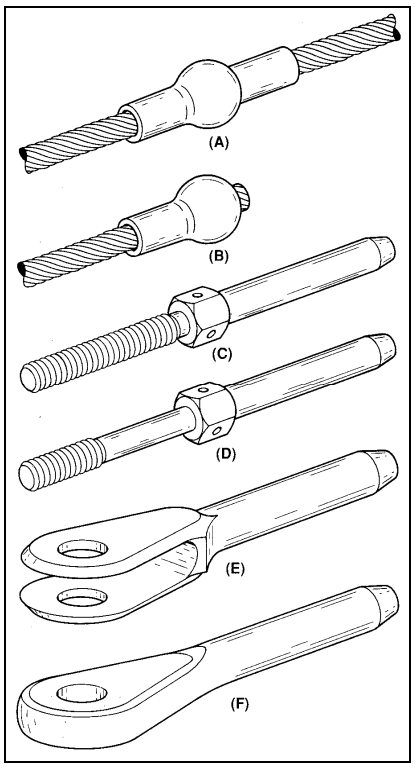
(C) 7 X 7 flexible cable

(D) 7 X 19 extra-flexible cable

Figure 78 Aircraft Cable Configuration

Cable Termination

The cable is usually terminated with a special fitting designed to simplify attachment and to help the cable maintain its shape. Two common terminations are discussed below.



Swaged terminals are crimped onto the wire end using a special tool. See figure 79. Once crimped the terminal and cable is checked with a go no go gauge to ensure that the joint has been properly crimped or swaged. see figure 80.

(A) MS20663C ball and double shank

(B) MS20664C ball and single shank

(C) MS21259 long threaded stud end

(D) MS21260 short threaded stud end

(E) MS20667 fork end

(F) MS20668 eye end

Figure 79 Swaged Cable Ends

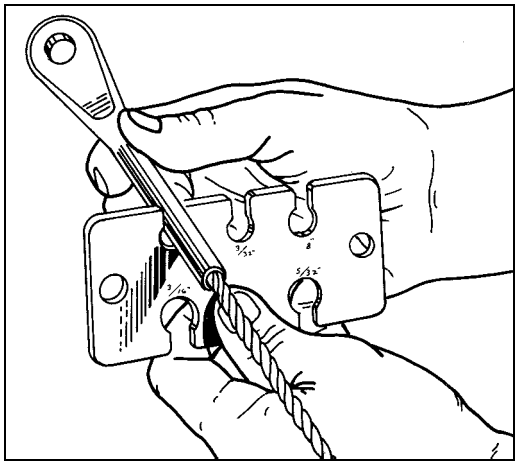
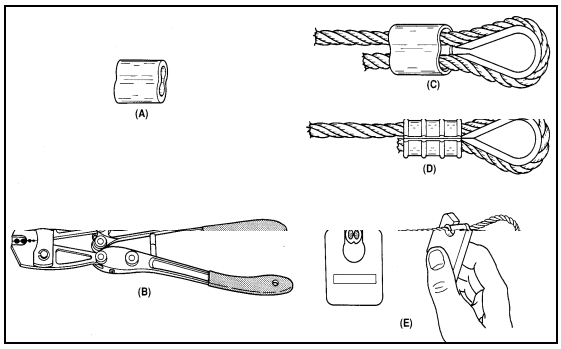


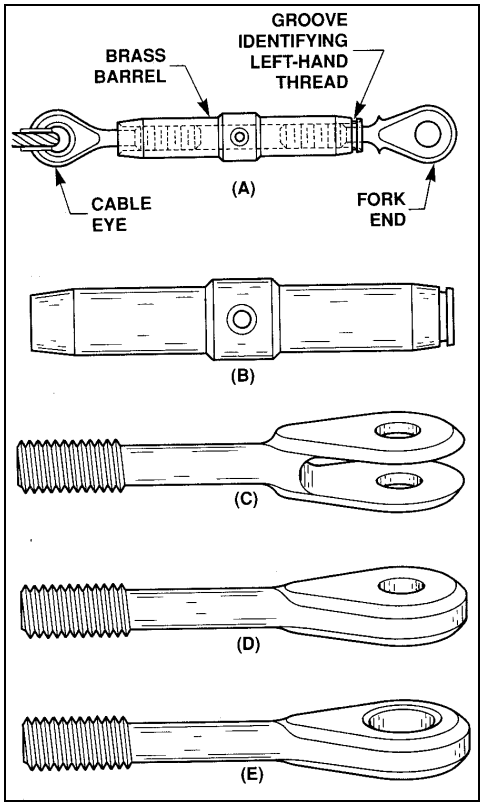
Figure 80 GO-NO-GO Checker

Nicopress Oval Sleeves are designed to be squeezed onto the cable end to allow loops or bights to be formed in the cable. In use a copper sleeve is placed over the cable end and the end is then doubled back and slipped into the opposite side of the sleeve. A proper size thimble is then placed inside the cable loop and the cable is pulled tight. The sleeve is then squeezed three times with the proper crimping tool. See figure 81.



(A) unused sleeve
(B) hand crimper
(C) slip sleeve on cable, bend cable back over thimble and stick through sleeve.
(D) 3 squeezes center then-thimble and then end.

Figure 81 Nicopress Oval Sleeving



Turnbuckles are used to adjust cable tension. A complete turnbuckle will consist of a brass barrel, an end piece with LH threads and an end piece with RH threads. Once adjusted the turnbuckle must have both ends safety wired to prevent loosening. See figure 82.

(A) assembled view
(B) barrel
(C) fork type end
(D) pin eye type end
(E) cable eye type end

Figure 82 Turnbuckle

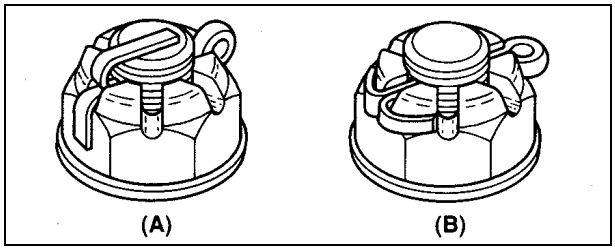
FITTINGS AND LOCKING DEVICES

When disassembling any component or assembly you must note exactly what locking and safetying devices and techniques have been used and you must also review all pertinent documentation to determine what measures are recommended by the manufacturer and regulatory agencies to ensure that all parts remain secure.

1. Safetying and Locking Techniques

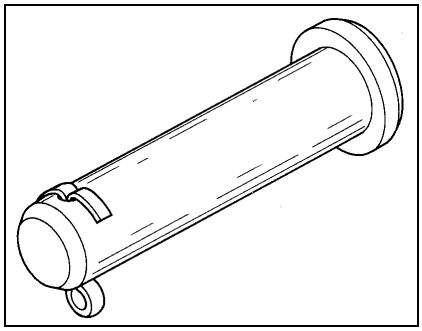
The following techniques and devices are recommended to ensure that vibration and varying loading and thermal cycles do cause components to "loosen" over time. These techniques and devices will also help to discourage tampering by unauthorized individuals.

Cotter pins/Safety pins
Friction Locks
Adhesives
Witness Marks
Jam Nuts
Tab Washers/Cup Washers
Circlips/Retaining Devices



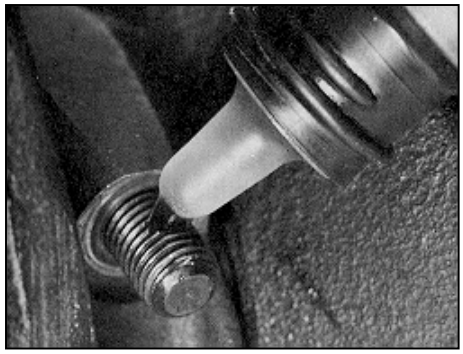
Cotter pins are used throughout the aircraft to prevent movable parts from separating. Cotter pins are installed through a predrilled hole, the legs are spread and then bent over to keep the pin from vibrating loose.

Safety pins are used to ensure that movable parts do not separate unless the pin is removed, see figure 88. Many explosive actuators will incorporate a safety pin in order to "safety" the system for storage or maintenance. Safety pins are also used on many hydraulic stands and jacks to prevent the ram from moving if hydraulic pressure is lost. Safety pins or ground locks are also used on aircraft undercarriages when parked.



The clevis pin may be used as a safety pin. in this case it is secured with a small cotter pin.

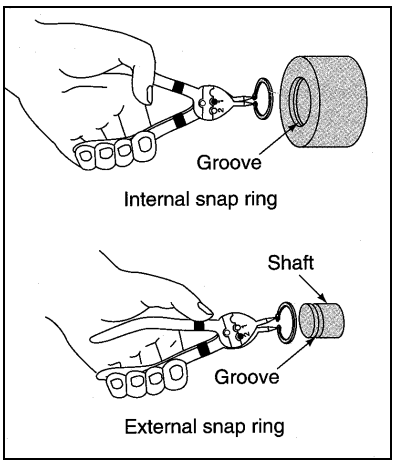
Friction locks are used on many lever type of aircraft controls. These locks use a pressure plate which is squeezed as the friction lock knob is turned or moved. The friction lock is used to hold aircraft controls in position and to avoid creep due to vibration.



Adhesives may be used in certain cases to help hardware to hold components together. Anaerobic sealant is often used on critical nuts and bolts for thread locking. As the sealant cures it "locks" the threads of the bolt to ensure tightness. Adhesives must be used when specified by the manufacturer. See figure 89.

Use thread-lock sparingly.

Figure 89 Thread-Locker



Circlips/Retaining Devices/Snap Rings are used to hold or retain a shaft in position. The ring is made of spring steel and is designed to snap into a groove machined around a shaft or into a groove machined inside a bore. See figure 90 for a typical snap ring insertion/removal.

The two ends must be spread not twisted.

Figure 90 Snap Ring Install/Remove

These devices require a special installation tool. Refer to figure 91 and 92 for typical insertion and removal tools.

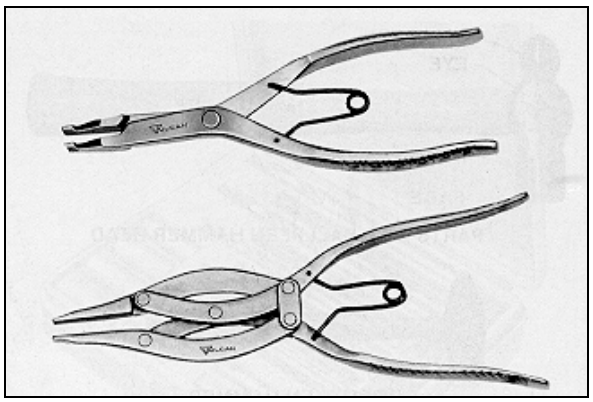


Figure 91 Snap Ring Pliers

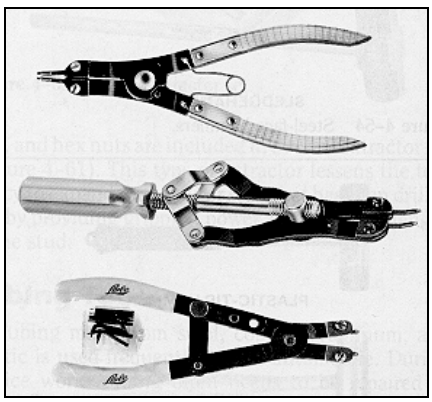
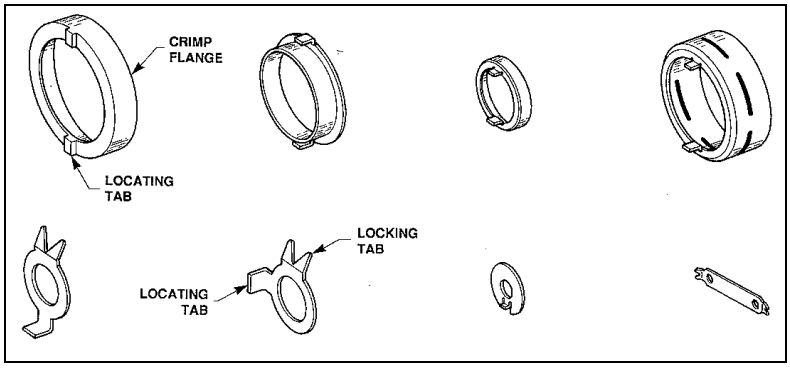


Figure 92 Retaining Ring Pliers

CAUTION

INSTALL AND REMOVE USING THE INSTALLATION TOOL.
THIS WILL AVOID TWISTING THE RING.

Jam Nuts are used to ensure that a nut does not loosen over time. The jam nut is simply threaded against the original nut to hold it secure.



Tab Washers are washers that have been produced with a protruding tab(s). In use, the tab will fit into a recess machined into the surface of the component. In some cases, once installed, the tap is bent or crimped to prevent loosening. See figure 93 for sample tab washers.

Figure 93 tab & Cup Washers

Cup Washers are made with a slightly dished shape. When installed the dish compresses and acts to apply a tension on the bolt and nut. This constant spring tension will ensure that the nut and bolt remain tight despite high levels of vibration. See figure 93.

Witness Marks are lines etched or painted across the nut/bolt and the work surface. The line is installed when the bolt is initially torqued. As long as the line remains straight it is assumed that the bolt has not loosened and turned.