

6.5.1 - SCREW THREADS

SCREW PRINCIPLES

Two of the most common fasteners used in aviation are the bolt and the screw. They are similar in that they both have threads. *Figure 5-1* illustrates the parts of the threads on a threaded fastener.

In general, screws differ from bolts in the following ways. Screws usually have lower material strength and a looser thread fit than a bolt. The shank of a screw is typically threaded along its entire length without a clearly defined grip. Most screws thread into the material they are intended to fasten and do not utilize a nut. A bolt, on the other hand, requires a nut for it to function.

Threaded fasteners allow parts to be fastened together with all of the strength that unthreaded fasteners provide. However unlike rivets and pins, threaded fasteners may be disassembled and reassembled an almost infinite number of times. Due to the large range of different available fasteners, great care must be taken to select the correct fastener for each particular installation.

THE INCLINED PLANE

The value of the wedge as a means of transmitting motion is well known. For a constant effort applied in driving a wedge, a smaller angle of inclination between the planes will cause a greater force to be exerted through a shorter distance. Conversely, a larger angle will cause less force to be exerted through a greater distance.

The action of the wedge may also be reversed, with the wedge moving when a force is applied to the inclined surface. This is seen when the angle is large. The larger the angle becomes, the more readily the motion is reversed. But no matter how small the angle may be, the resulting forces will still tend to produce movement.

When a continuous inclined plane is cut around the outside or inside of a cylinder, then a spiral known as a helix is produced. The helix angle is important because it dictates the number of threads which can be cut per axial increment in the cylinder.

SCREW NOMENCLATURE

The difference between a bolt and a screw are sometimes disputed, but it is more often agreed that a bolt is considered to be a threaded fastener which has a

definite plain portion on the shank between its head and the beginning of the thread and is used together with a nut, while a screw is threaded all the way to the head. However because there are so many variations in terminology between different manufacturers, the only safe way to identify a fastener is to use the identical terminology as in the manufacturer's illustrated parts catalog when selecting or ordering replacements.

BOLT AND SCREW TERMINOLOGY

Figure 5-1 illustrates the parts of a bolt which is generally the same for a screw. A common screw and a machine screw are illustrated in *Figure 5-2*. Note that there are several types of structural screws such as the machine screw which also uses a nut like a bolt. Also note that the length of a countersunk screw is measured from the top of the head.

SCREW THREAD TERMINOLOGY

Figure 5-3 illustrates the parts of the threads on a threaded fastener.

- Major Diameter – the crest to crest distance of the thread is known as the major diameter.
- Minor Diameter – the root to root distance of the thread is known as the minor diameter.

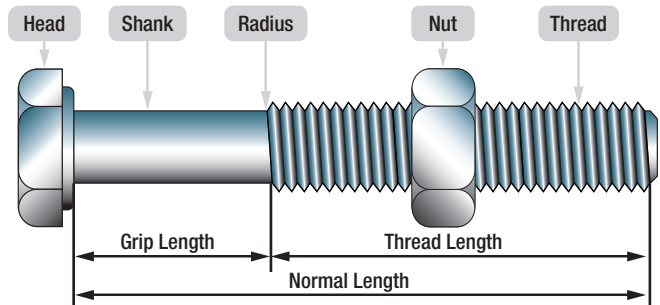


Figure 5-1. Bolt and screw terminology.

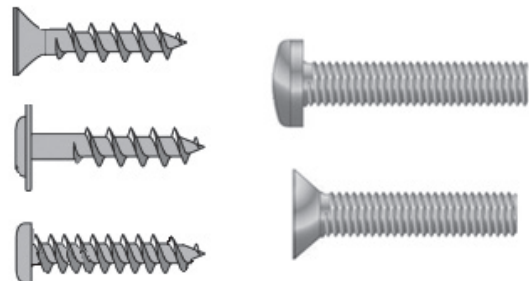


Figure 5-2. Common screws and machine screws.

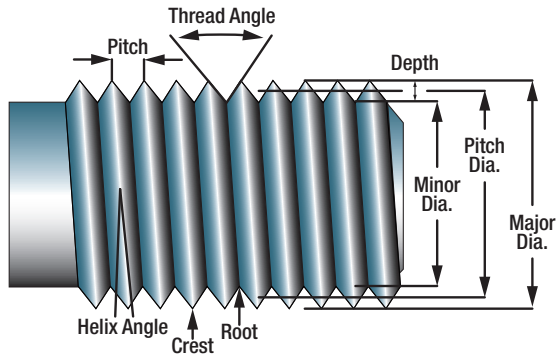


Figure 5-3. Threaded fastener nomenclature.

- Pitch – The distance from the center of one crest to the center of the next as measured parallel to the axis.
- Flank – the surface of the thread which connects the root to the crest.
- Lead – The distance a screw moves axially in one complete turn.
- Runout – the part of the thread where the minor diameter increases until it equals the major diameter and merges with the plain portion of the shank.

THREAD FORMS, DIMENSIONS AND TOLERANCES

COARSE AND FINE PITCH THREADS

Two screw threads may have the same major diameter and similar form but different depths of thread. The screw with deep thread will have fewer threads per inch and so pitch is said to be coarser than the screw with the shallow thread. The coarse pitch thread will have greater lead than the fine pitch thread but the minor diameter will be less and so less strength. A screw with fine pitch thread will have stronger crest position, tighter grip, finer adjustment and resistance to vibration. (*Figure 5-4*)

SINGLE AND MULTI START THREADS

A single start thread is when there is only one screw thread cut in the material. A multi-start thread consists of two or more separate parallel threads cut into the material carrying the thread. (*Figure 5-5*)

SCREW THREAD PROFILE

Forms of screw threads vary according to the purpose for which they are used and also according to the country in which they are manufactured. Most threads are V form, but some are square form, or modifications of either, or both.

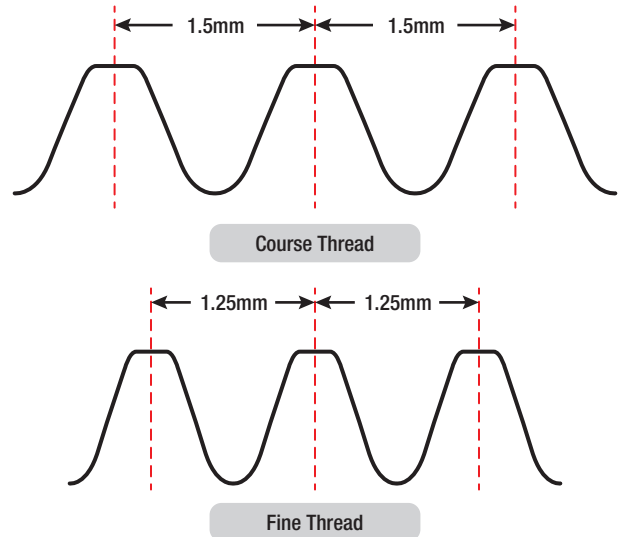


Figure 5-4. Course and fine pitch threads.

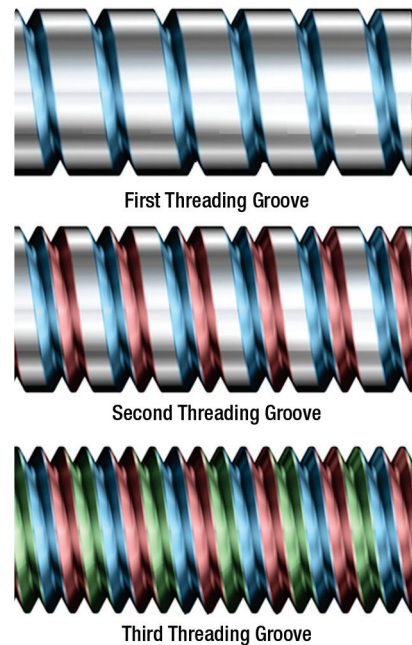


Figure 5-5. Single and multi start threads.

INTERNATIONAL THREAD SYSTEM

Aircraft screws, bolts, and nuts are manufactured to many different international standards and in a variety of thread forms. Most aircraft now use unified or metric threads but some older aircraft use the obsolete British Standard or Whitworth thread forms. None of these are compatible with the unified or metric forms.

Unified Screw Thread

These threads are of two basic series in which diameter is related to pitch. Both use the same thread form and are designated as United Coarse Thread (UNC) and

United Fine Thread (UNF). The UNC series covers sizes ranging from ¼" major diameter to 4". The UNF are available in fractional sizes from ¼" to ½".

Metric Screw Thread

Metric screw threads have a thread angle of 60°. Those used in aerospace use the MJ profile which is suitable for highly stressed applications. The MJ profile is a metric version similar to UNJ thread. Aerospace screws, bolts, and nuts are manufactured in diameter and pitch variations from 1.6 mm to 39 mm. The metric thread is identified by the letters MJ to identify metric followed by the size and pitch in millimeters and followed by the tolerance class. For example MJ6 × 1-3

CHOOSING THREADED FASTENERS

There are a wide variety of fastener styles, each with their own properties. It is important that only the fastener specified for a particular location be used in that location. Installation of the incorrect type of fastener may have catastrophic consequences. The illustrated parts catalog for the aircraft or equipment specifies each fastener by part number. The part number must always be used to identify the parts needed for any job. When a part has been superseded, an alternate part can only be substituted under suitable authority. One source of information on acceptable alternatives is the Structural Repair Manual (SRM) of that aircraft which gives a recognized substitutions table.

Note that thread types are not interchangeable. For example, a UNF screw must be used only in a UNF nut of the same size. The size of the hole to be drilled for tapping an internal thread and holes for screw clearance are given in the applicable national standard. However tapping and clearance drill sizes are reproduced in readily available charts such as ZEUS reference tables.

THREAD TOLERANCES

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.

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.

MEASURING SCREW THREADS

SCREW THREAD PITCH

Screw thread pitch on a screw, bolt, or tapped hole can be verified and measured with a screw thread pitch gauge as shown in *Figure 5-6*. Gauges are available for most thread patterns as discussed above. To use, simply match the threads on any screw or bolt to the threaded edge of the leaf. If the threads align perfectly you have identified the thread pitch correctly.

GO-NOGO GAUGES

Go-NoGo gauges such as shown in *Figure 5-7* provide a quick way to judge whether a threaded plug will properly fit into a threaded hole within tolerance limits. Be careful not to force the gauge into the test hole, especially on thin walled parts, as an incorrect attempt could easily distort the receptacle.

It is important that all thread gauges should be checked periodically to ensure that they are not worn beyond permissible limits or otherwise damaged. Checking is normally done by skilled inspectors. Gauges used continuously should be checked daily. Those used intermittently should be checked weekly.

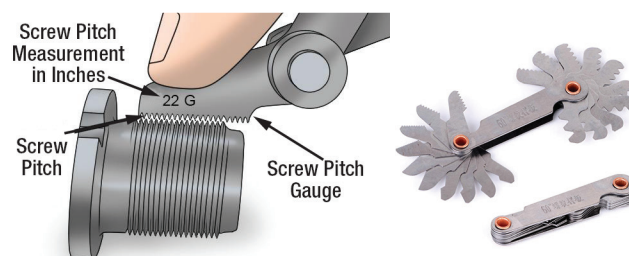


Figure 5-6. Screw thread pitch tools.



Figure 5-7. Go-NoGo gauges.

6.5.2 - BOLTS, STUDS AND SCREWS

BOLT TYPES: SPECIFICATIONS, IDENTIFICATION, AND MARKING OF AIRCRAFT BOLTS, INTERNATIONAL STANDARDS

AIRCRAFT BOLT TYPES

Aircraft bolts are fabricated from cadmium or zincplated corrosion resistant steel, unplated corrosion resistant steel, or 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 manufacturer's 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. NAS bolts are available in hex head, internal wrenching, and countersunk head styles. MS bolts come in hex head and internal wrenching styles. (*Figure 5-8*)

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 bolt heads.

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 ($\frac{3}{16}$), 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 ($\frac{5}{8}$), 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.

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 (0.006-inch clearance for a $\frac{5}{8}$ -inch hole, and other sizes in proportion). Alloy steel bolts smaller than No. 10-32 and aluminum alloy bolts smaller than $\frac{1}{4}$ inch in 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.)

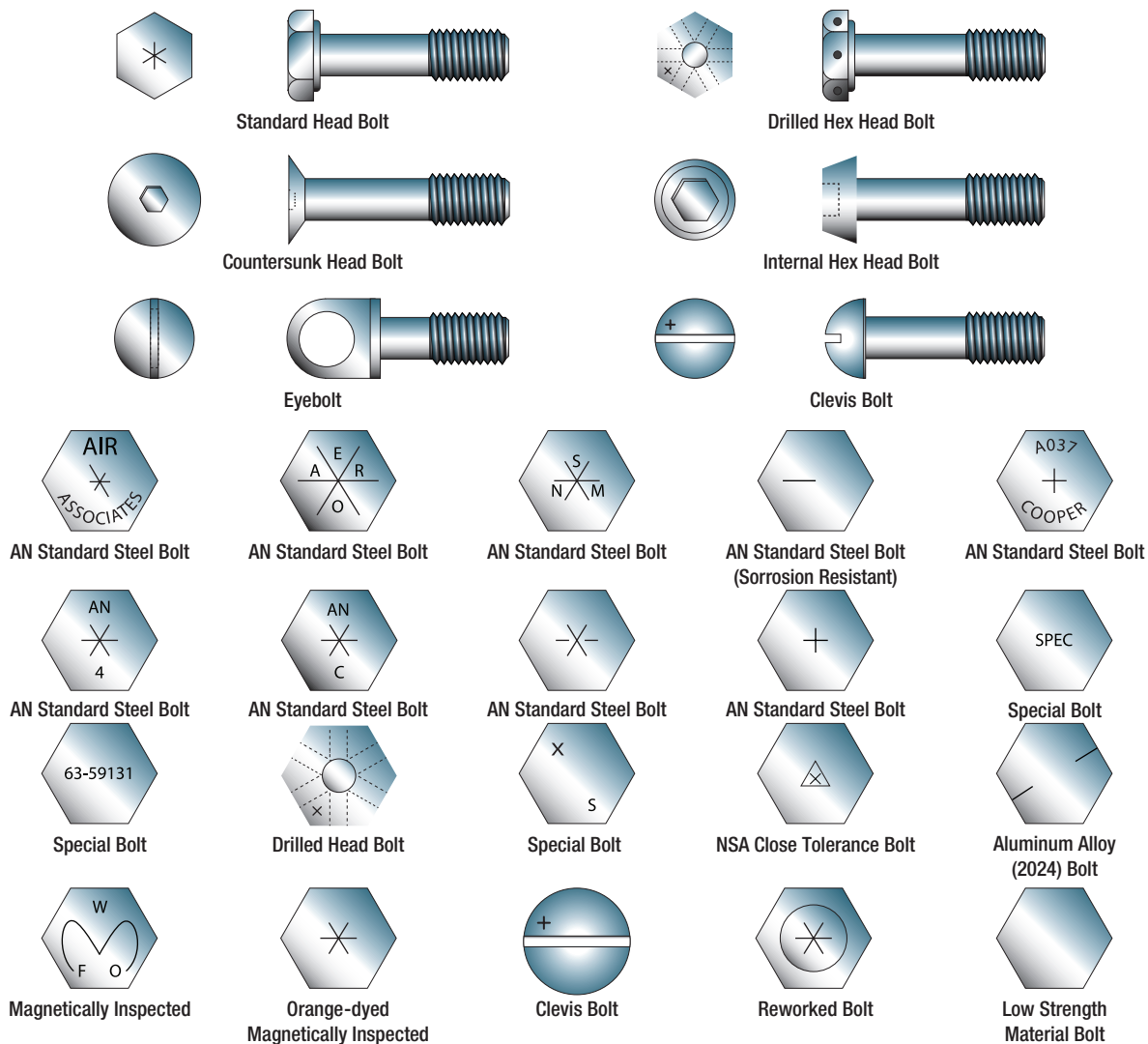


Figure 5-8. Aircraft bolt identification.

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 bolt hole 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.

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 eyebolt 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 blind fastener. The Jo-bolt consists of three parts: a threaded steel-alloy bolt, a threaded steel nut, and an expandable stainless steel sleeve. (Figure 5-9)

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 that 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:

- 200 series, approximately $\frac{3}{16}$ inch in diameter.
- 260 series, approximately $\frac{1}{4}$ inch in diameter.
- 312 series, approximately $\frac{5}{16}$ inch in diameter.
- 375 series, approximately $\frac{3}{8}$ inch in diameter.

Jo-bolts are available in three head styles: F (flush), P (hex head), and FA (flush millable).

Lockbolts

Lockbolts are used to attach two materials permanently. They are lightweight and are equal in strength to standard bolts. Lockbolts are manufactured by several companies and conform to Military Standards. Military Standards specify the size of a lockbolt's head in relation to the shank diameter, plus the alloy used in its construction. The only drawback to lockbolt installations is that they are not easily removable compared to nuts and bolts.

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



Figure 5-9. A Jo-Bolt fastener.

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. (Figure 5-10)

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

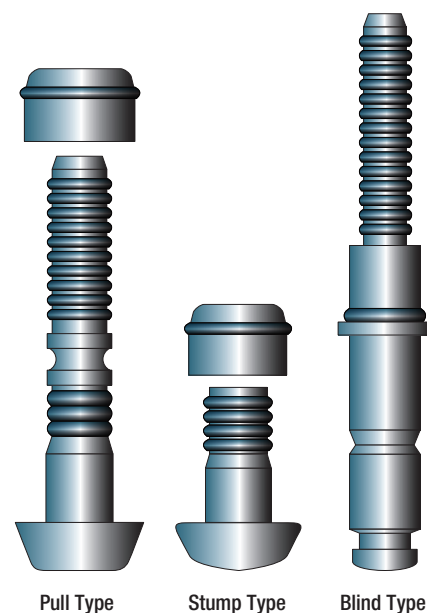


Figure 5-10. Lockbolt types.