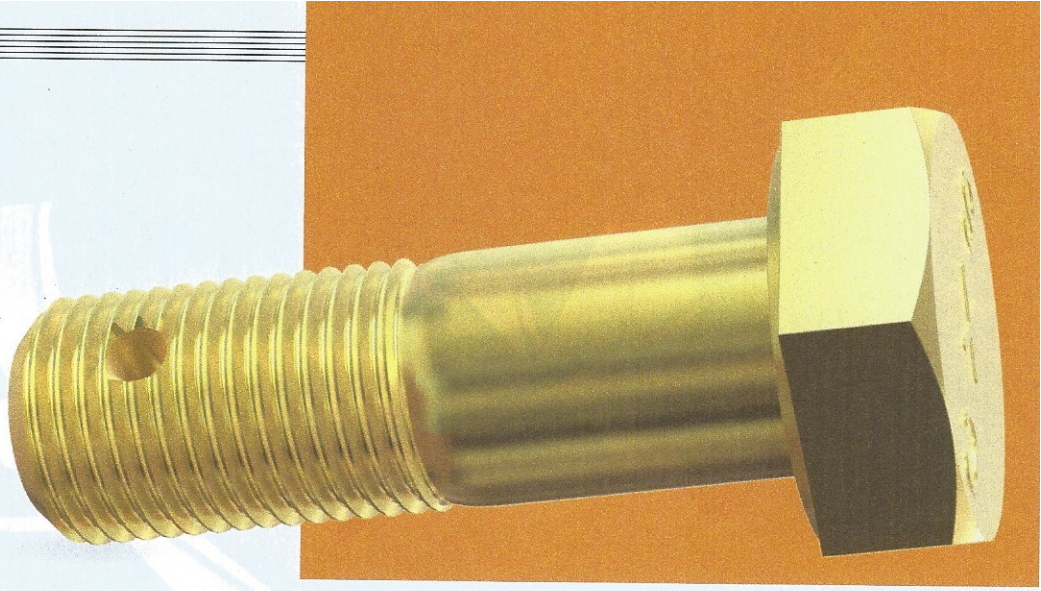
HARDWARE



Bolt Basics

Most commonly used types in experimental aircraft

BY BRIAN AND CAROL CARPENTER

WE ARE OFTEN REMINDED by students attending our maintenance classes just how confusing hardware identification can be. After 40 years in the business and dealing with hardware on a daily basis, we often take for granted all of that seemingly generic information that was, at one point, a mystery to us as well. Handing a student a 200-page manual with literally thousands of different types of nuts and bolts that are rarely used doesn't really help the situation. In reality, the average homebuilt aircraft uses a small selection of different hardware that is universal to the majority of experimental aircraft.

The AN bolt is nearly as old as aviation, and it is the backbone of the aircraft construction process. If you're thinking of building your first aircraft, you will inevitably become friends with this venerable piece of hardware.

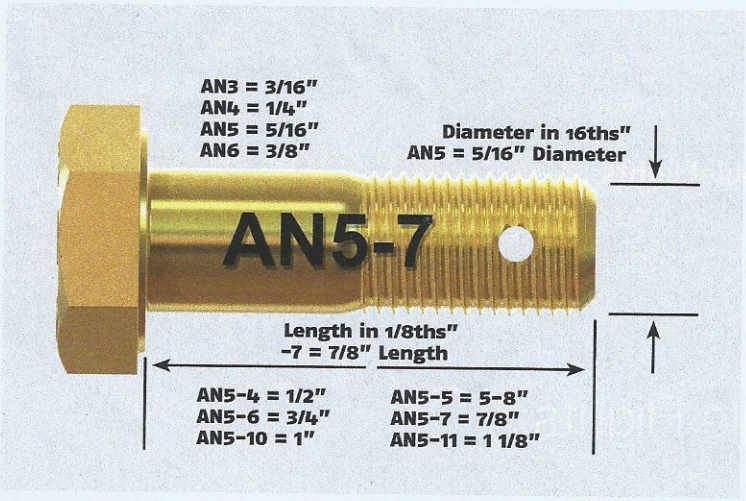


Figure 1: Bolt sizing.

The reason for this: Kit manufacturers couldn't compete in the marketplace if they were constantly sourcing obscure and costly hardware. So, rather than writing about the hundreds of different types of bolts available, we want to focus on the basic bolts used on the majority of experimental aircraft built today.

The standard aircraft machine bolt is the AN3 through AN20. The AN in the part number identifies that these particular bolts conform to a specification called the Army-Navy standards. The first number refers to the diameter of the bolt in 1/16 of an inch (Figure 1). The "dash" number refers to the length of bolt in 1/8 of an inch. When we reach lengths greater than 7/8 of an inch, we refer to the first number as the number in whole inches and the second number in 1/8 of an inch. For example, a 1-inch bolt is a -10, a -20 is 2 inches, and a -35 is 3-5/8 inches.

It is important to point out that this is a generic numbering system. In reality, both the length and the grip of the bolts vary depending on diameter. This is the reason that it is essential to use a bolt gauge when measuring the length of bolts and to use a bolt chart when ordering. With that said, let's look at some simple modifications to the bolt and subsequently the part number. There are two basic machining options available to the basic AN bolt. The first is a drilled hole in the shank,

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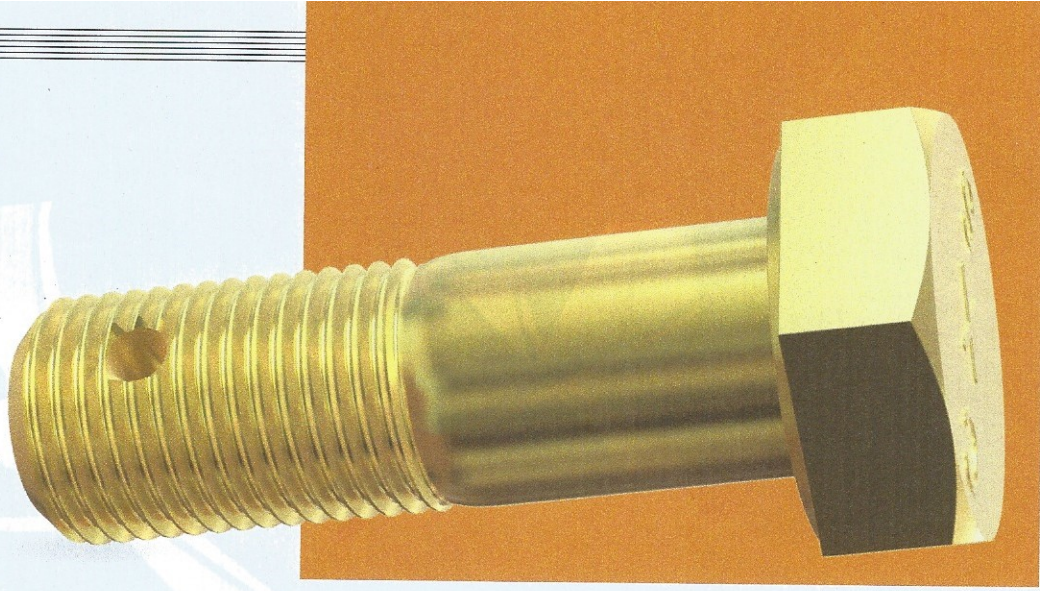
HARDWARE



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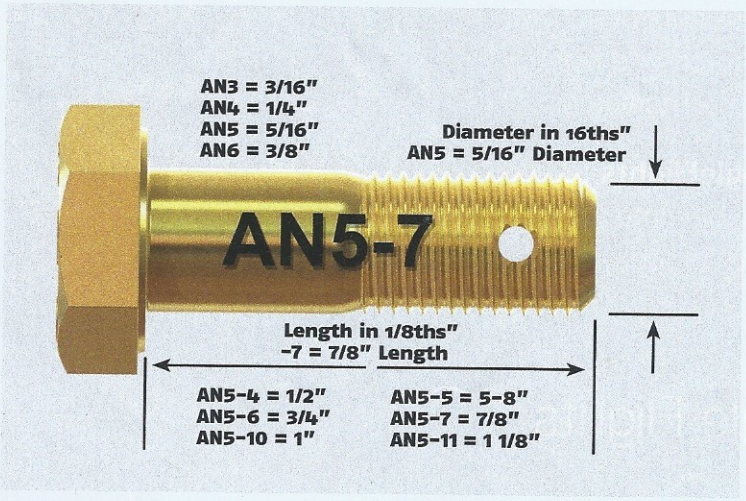

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Figure 2: *Safety wire and cotter pin holes.*

Figure 3: *Bolt material composition.*

which allows the use of a cotter pin and castle nut. In this case, the addendum to the part number can be rather counterintuitive. If we would like to purchase a bolt without a hole in the shank for a cotter pin and castle nut, we are required to add an A to the end of the part number (for example AN5-7A). Without the A the bolt will automatically have the hole drilled in the shank (Figure 2). The second modification is the drilling of the bolt head for the purpose of safety wiring. This part number addendum makes a bit more sense. We simply add an H after the basic part number, but before the dash number, for a bolt with a drilled head (for example AN5H-7A). You may also find several references that leave the dash out of the part number once the basic part number has been modified with a letter (for example AN5H7A).

The last possible modification to the AN bolt is not a machining modification, but rather a materials modification (Figure 3). The standard steel AN bolt standards call for a high-strength 8740 alloy steel, with a tensile strength of around 125,000-145,000 psi. These standard bolts are centerless ground and roll threaded after heat treatment, then cadmium plated. It is this gold iridescent cadmium plating that makes the standard steel bolt easy to identify at first glance, but it is the head markings that we use for positive identification.

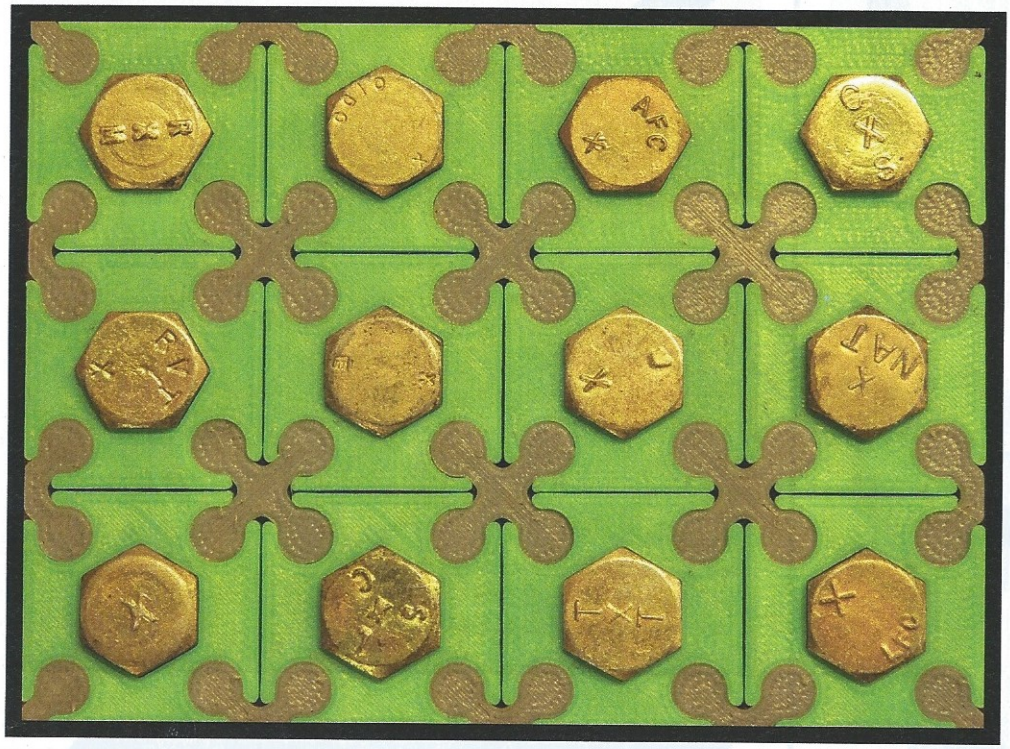

Figure 4: AN5 bolts from various manufacturers.

The X stamped or raised onto the head of the bolt is the primary identifier of a standard steel AN bolt. To the uninitiated, this can be quite confusing. Pick up just about any AN bolt and you will see all manner of markings. These markings are the manufacturer's identification markings (Figure 4). For this article, we searched the shop and easily found a selection of a dozen different manufacturers on just AN5 bolts. At random, we selected a bolt for 3D modeling with CS emblazoned on the head. Afterward, we were able to look up and identify the manufacturer as California Screw Products. Generally, it's pretty easy to distinguish the manufacturer's marks from the material identification markings. There are only three materials and subsequently three markings to identify.

Similar to the X, the next material, corrosion-resistant steel, is identified with a single raised or recessed dash marking on the head. In addition, the corrosion-resistant steel is unplated and sports that gunmetal gray color that makes the material easy to identify at a glance. The addition of the C after the basic part number identifies the bolt as a corrosion-resistant steel bolt (for example, AN5C-7A). These bolts are manufactured from 431-grade stainless steel. This is a martensitic-grade straight chromium steel containing almost no nickel and, as a result, is quite magnetic. The 431 grade is used for its combination of hardness, strength, and wear resistance while still retaining superior corrosion-resistance properties. The tensile strength is around 125,000 psi.

Juxtaposed to the two steel bolts is the 2024 aluminum alloy bolt with a tensile strength of around 62,000 psi. This bolt is also readily identifiable. The anodized color is the first clue. In contrast to the other two steel bolts, the aluminum bolt is nonmagnetic. However, the dead giveaway is when you pick up an aluminum bolt it is dramatically lighter than you would anticipate. To positively identify the bolt as an aluminum bolt, the head markings are a double dash (- -). The addition of DD after the basic part number identifies the bolt as an aluminum bolt (for example, AN5DD-7A).

All of these bolts share a few universal characteristics. The standard AN bolt thread is the unified national fine (UNF) thread (Figure 5). This is based on a 60-degree thread that forms an equilateral triangle, with the exception that the root of the threads are rounded during the thread rolling process. Rolled threads minimize stress concentrations and significantly enhance the strength across the threaded section of the bolt. It is literally the difference between forging and machining a piece of metal (Figure 6). Cutting additional threads with a die is considered a major faux pas. This is because the pointed end of a die is cutting into the material, leaving a stress concentration.

Notes on torquing bolts: Unless otherwise specified, for a particular installation the bolts should be torqued dry. It is interesting to note that only about 15 percent of the torque applied during the torquing process increases the bolt tension. Around 45 percent of the turning force is required to overcome the friction between the male and female threads. Any oil, anti-seize compound, or other lubricants present on the threads during the torquing can significantly reduce the friction.

AN-3	32 TPI
AN-4	28 TPI
AN-5	24 TPI
AN-6	24 TPI
AN-7	20 TPI
AN-8	20 TPI

Figure 5: Thread pitch.

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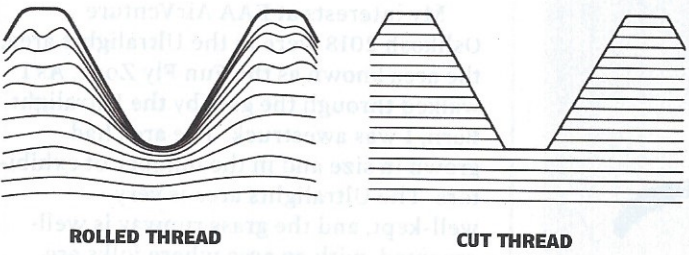


Figure 6: Rolled versus cut threads.

The standard aircraft machine bolt is the AN3 through AN20. The AN in the part number identifies that these particular bolts conform to a specification called the Army-Navy standards.

This can lead to a significant increase in the actual tension applied to the bolt, even to the point where the tension on the bolt is stressed beyond its yield point. This could easily lead to premature failure. The cadmium plating on the standard steel bolts for corrosion protection also acts as a lubricant. The standard torque table specifications take this into account, and no adjustment is needed. But it brings up the point that installing old rusty hardware with the cadmium plating missing may actually lead to a reduced torque value as a result of increased friction at the thread interface.

The purpose of torquing the bolt is to apply a preload. This has the effect of reducing the bolt's exposure to fatigue cycles. When using lock nuts, either nylon or all metal, there is a friction drag component created by the locking device. On critical application bolts, it is common practice to measure the friction drag torque required to turn the nut, and then add that value to the desired torque setting to come up with our final torque. Additionally, structural assemblies exposed to continuous flight loads may settle in, reducing the preload on the bolt. Components exposed to thermal cycling or installed with a gasket may also lose their preload. This is the primary reason a manufacturer may call for a retorquing interval to once again establish the proper preload on the bolt.

The AN bolt is nearly as old as aviation, and it is the backbone of the aircraft construction process. If you're thinking of building your first aircraft, you will inevitably become friends with this venerable piece of hardware. And if you've already built an aircraft, it's always good to get reacquainted with a friend, especially if that friend is holding the wings onto the rest of your aircraft. *EAA*

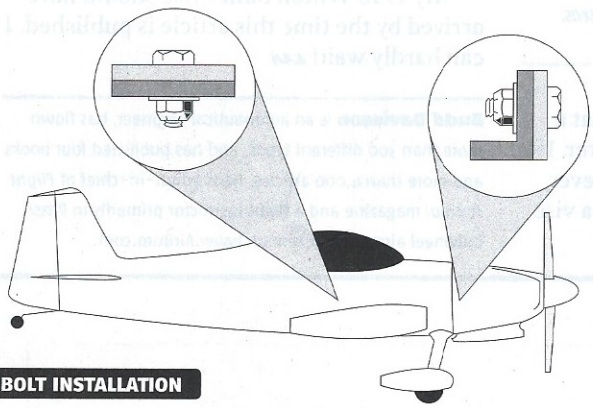
Carol and Brian Carpenter, EAA 678959 and 299858, owners of Rainbow Aviation Services, have co-authored two aviation books and team teach the Light Sport Repairman Workshops. Brian is a CFII, DAR, A&P/IA, and the designer of the EMG-6 (an electric motorglider). Carol is an SPI, PP, LSRM, and FAAST representative.

HOW-TO

HARDWARE ESSENTIALS

Editor's note: This is adapted from a hint that first appeared in the January 2003 issue of EAA's *Experimenter*.

HERE'S A HANDY REFERENCE for your workshop. These illustrations demonstrate the standard use of AN hardware in structural applications. Some of them are courtesy of Ron Wanttaja, while the rest are re-created from Tony Bingelis' book *Sportplane Construction Techniques*. This title as well as Tony's other books are available directly from EAA — just go to www.EAA.org and click Shop, or call 1-800-564-6322. The AN hardware reference table was compiled based on information from FAA Advisory Circular 43.13-1B, *Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair*, which can be downloaded via the link at www.EAA.org/extras.

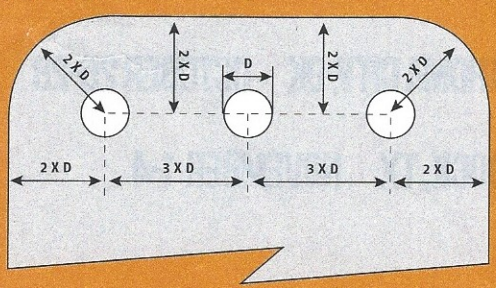


BOLT INSTALLATION

Bolt heads *up* and *forward*, when possible.

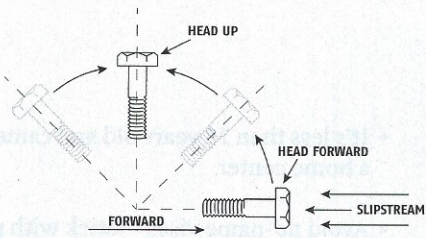
EDGE MARGIN

Edge margin is the minimum distance a hole should be placed from either the edge of a piece of metal or another hole.

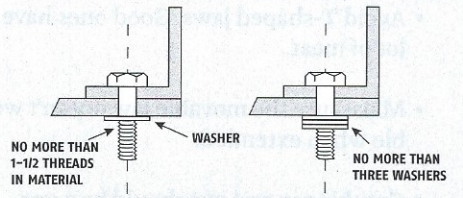


DIAMETER (D)	2xD	3xD
3/32	3/16	9/32
1/8	1/4	3/8
3/16 (AN3)	3/8	9/16
1/4 (AN4)	1/2	3/4
5/16 (AN5)	5/8	15/16
3/8 (AN6)	3/4	1-1/8
7/16 (AN7)	7/8	1-5/16
1/2 (AN8)	1	1-1/2

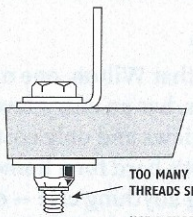
BOLT INSTALLATION BASICS



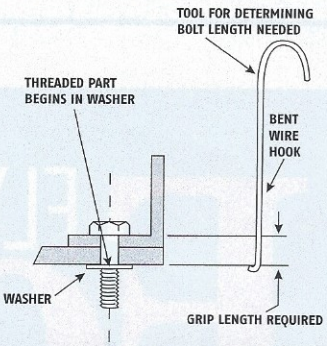
MINIMUM VS. MAXIMUM GRIP LENGTH



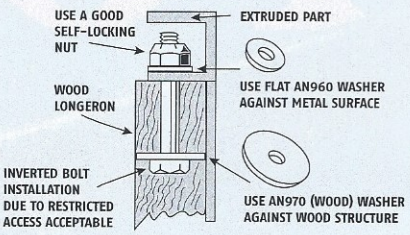
THREAD LENGTH



HOW TO DETERMINE CORRECT BOLT LENGTH



INVERTED BOLT INSTALLATION



AN HARDWARE QUICK REFERENCE

BOLT	WRENCH SIZE	NUT NY-LOCK	NUT (CASTLE)	WASHER STD	WASHER LG.	COTTER PIN	TORQUE RECOMMENDED	TORQUE MAX
AN 3	3/8	AN365-1032	AN310-3	AN960-10	AN970-3	MS24665-132	20-25 IN. LBS.	40 IN. LBS.
AN 4	7/16	AN365-428	AN310-4	AN960-416	AN970-4	MS24665-132	50-70 IN. LBS.	100 IN. LBS.
AN 5	1/2	AN365-524	AN310-5	AN960-516	AN970-5	MS24665-134	100-140 IN. LBS.	225 IN. LBS.
AN 6	9/16	AN365-624	AN310-6	AN960-616	AN970-6	MS24665-283	160-190 IN. LBS.	390 IN. LBS.

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