Bolt Basics

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 all of 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 home built aircraft uses a small selection of different hardware that is universal to the majority of experimental aircraft. 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 AN-20). The "AN" in the part number identifies that these particular bolts conform to a specification called the the Air Force-Navy standards. The first number refers to the diameter of the bolt in 1/16ths of an inch.(Figure: 1) The "dash" number refers to the length of bolt in 1/8ths of an inch. When we reach lenghs greater than 7/8 of an inch, we refer to the first number as the number in whole inches and the second number in 1/8ths of an inch. For example, a 1 inch bolt is a -10, a -20 = 2", and a -35 = 3 and 5/8". Now that we have explained the basic numbering system for the length, 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 using 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, 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 pur-

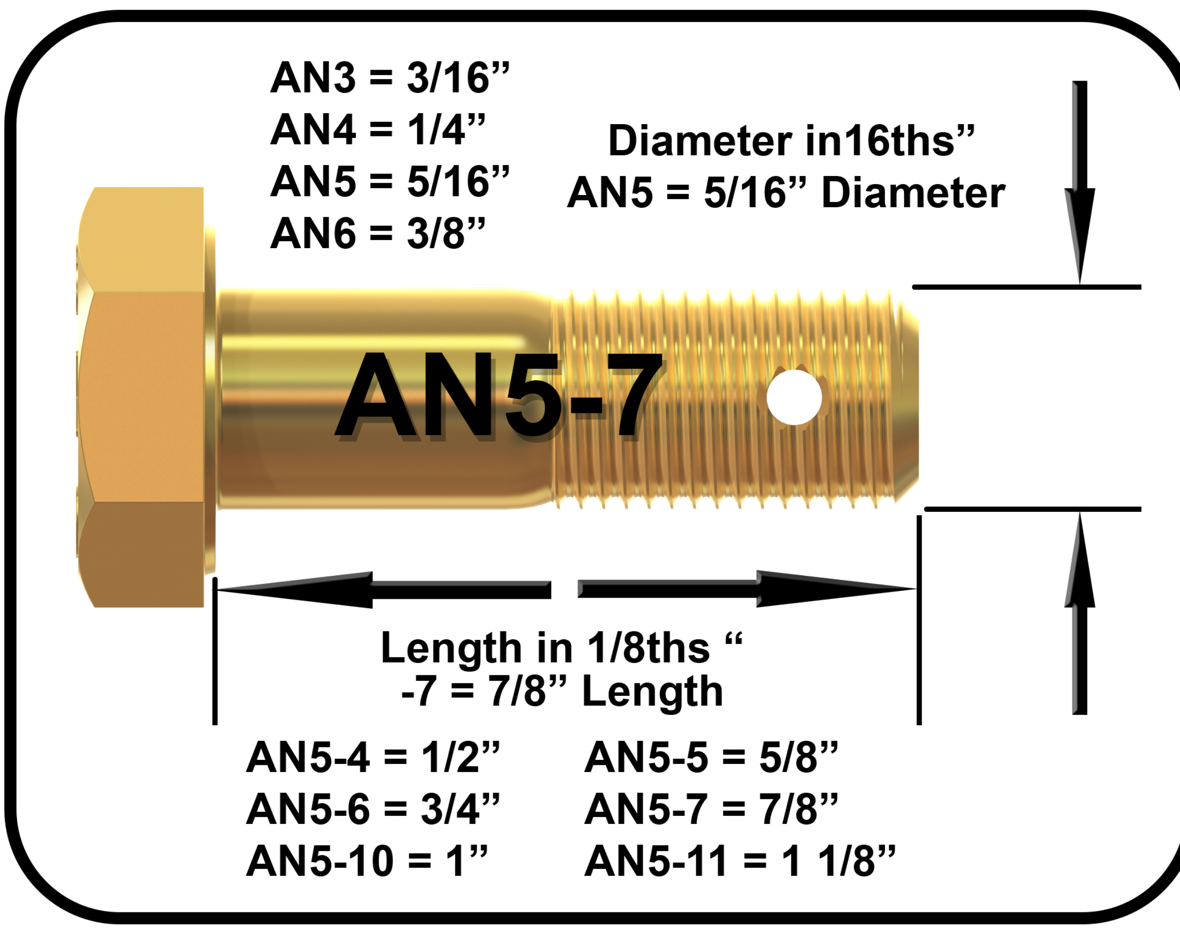
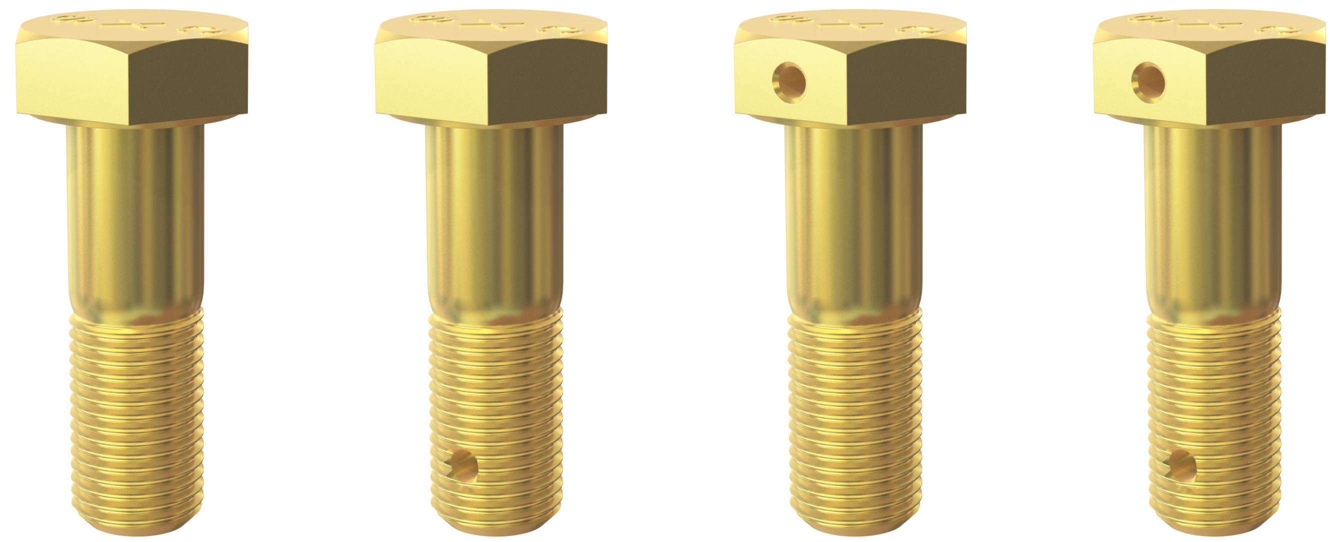


Figure: 1 Bolt Sizing

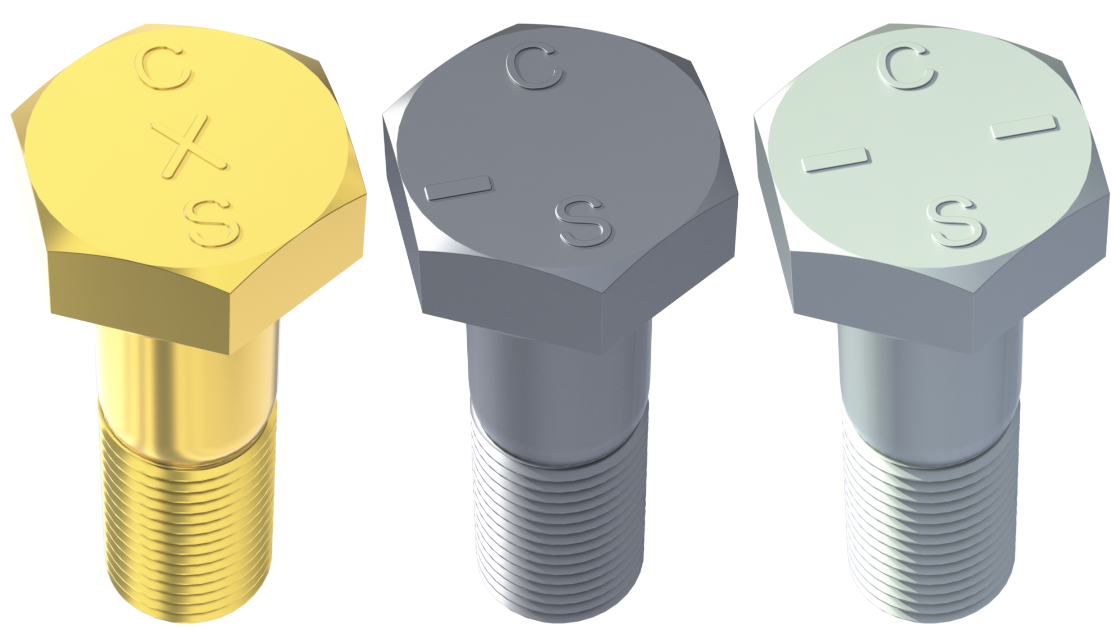


AN5-7A No Holes | **AN5-7** Cotter Pin Hole in Shank | **AN5H-7A** Safety Wire Hole in Bolt Head | **AN5H-7** Safety Wire Hole and Cotter Pin Hole

Figure: 2 Safety Wire and Cotter Pin Holes

chase 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 whole 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 a "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).

Last, but not least, there is one more possible modification to the AN bolt. 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 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. 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



AN5-7A Standard Alloy Steel | **AN5C-7A** Corrosion Resistant Steel | **AN5DD-7A** 2024 Alloy Aluminum

Figure: 3 Bolt Material Composition

markings are manufacturers identification markings. (Figure: 4) For this article we searched the shop and easily found a selection of dozen different manufacturers on just AN5 bolts. At random we selected a bolt for 3D modeling with “CS” emblazoned on the head. Afterwards, we were able to look up and identify the manufacturer as California Screw Products. Generally, it’s pretty easy to distinguish the manufacturers marks from the material identification markings.

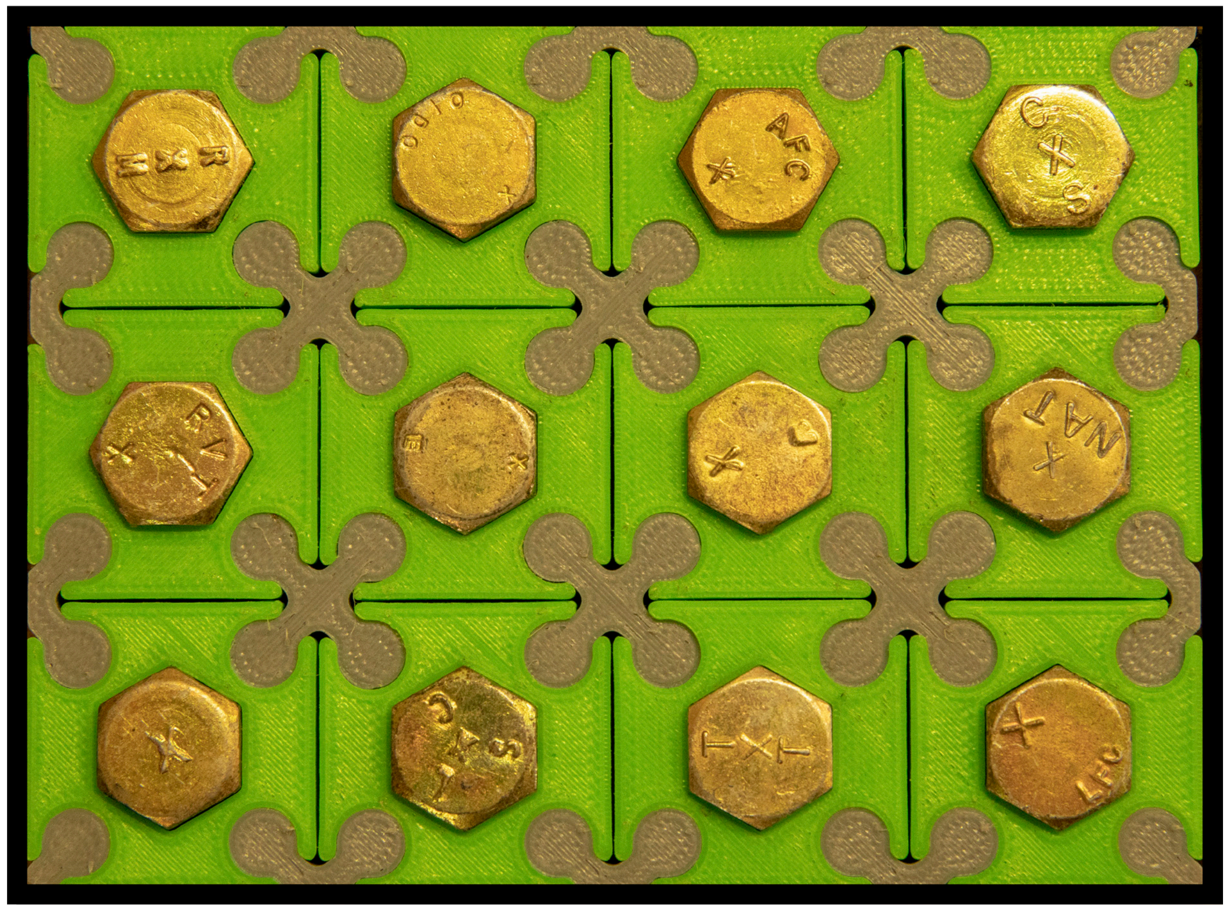


Figure: 4 *AN5 Bolts From Various Manufacturers*

There are only three materials and subsequently three markings to identify. We have talked about the “X”, so let’s move on to 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 un-plated, and sports that gunmetal gray color that make 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 stanless steel. This is a martensitic grade straight chromium steel containing no nickel, and as a result, quite magnetic. 431 is used for its combination of hardness, strength, and wear resistance while still retaining superior corrosion resistance properties. The tensile strength is around125,000 psi. Juxtaposed to the two steel bolts we have 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 and aluminum bolt (for example AN5DD-7A).

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

Let’s also identify some characteristics that are universal to all of these bolts. The standard AN bolt thread is the ‘Unified National Fine’ (UNF) thread. (Figure: 5) This is based on a 60° 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.

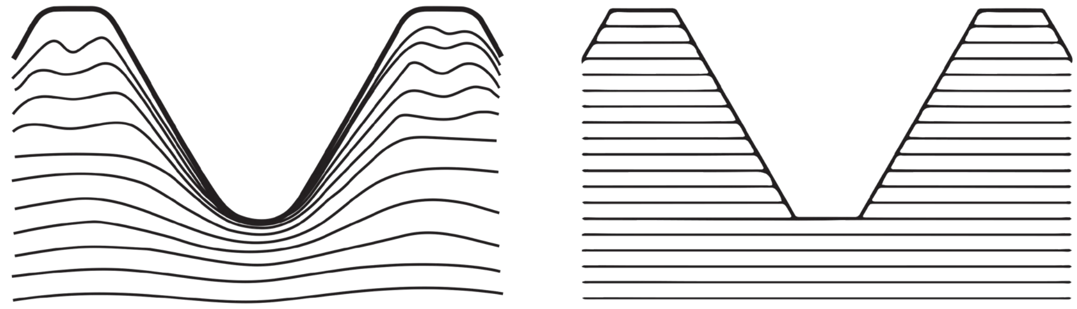


Figure: 6 Rolled vs Cut Threads

Notes on Torqing Bolts: Unless otherwise specified, for a particular installation, the bolts should be torqued “Dry”. It is interesting to note that only about 15% of the torque applied during the torquing process increases the bolt tension. But around 45% 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. 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 possible 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, 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 lock nuts, 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. Additionally, components exposed to thermal cycling or installed with a gasket may also lose their preload. This is primary reason that a manufacturer may call for a re-torquing 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.