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Understanding Aircraft Hardware

by Kas Thomas

Anyone who's spent any time at all working on aircraft must (at some time or another) have felt like Goldie Hawn in the movie *Swing Shift* where—as an aircraft-factory worker in WWII—she's cruelly made fun of for believing that there is such a thing as a *left-handed* safety-wire twister. (Actually, the joke is on the movie producers: Wire-twisting pliers do, in fact, come in right- and left-handed versions.) Unfamiliarity with aircraft hardware can leave one feeling—well, ignorant.

Suppose your A&P asks you to hand him a Tinnerman nut. Would you know that this is the term for those tiny square stampings that back up the screws in your inspection plates and tailcone?

What if you've taken something apart—like a main wheel—and the service manual for your plane doesn't list the reassembly torque for the tie-bolts? Would you know how to proceed? (First look on the wheel halves. If no torque is given there, go to an FAA Standard Torque Table, such as p. 134 of AC 65-9A, and look up the torque according to the AN number of the bolt.)

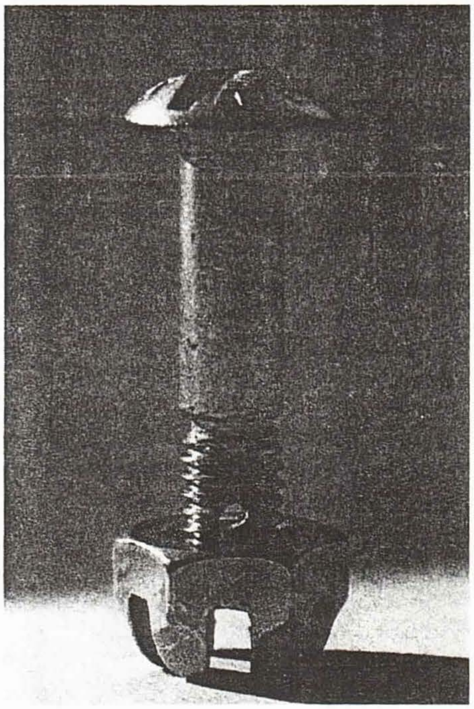
What do you do if you come across an aluminum nut on a steel bolt? Would you know that AC 65-9A allows such a combo for *shear-loaded* bolts only (and only on land planes; not seaplanes)?

If you answered no to any of these, perhaps it's time for a refresher.

Bolt Lore

One of the most important questions of all is: How can you tell an "aircraft" bolt from a non-aircraft (hardware-store; junk) bolt? First thing is, you look at the head of the bolt. If it's clean and contains no raised markings you're dealing with barnyard-variety hardware. Don't use it on an airplane.

Bolts for aircraft are either AN (Air Force-Navy), MS (Military Standard), or NAS (National Aircraft Standard).



A variety of head markings are used, the most common being the six-pointed raised asterisk (or raised cross) of the AN bolt. All aircraft bolt heads have a raised marking of some sort. It may include the manufacturer's initials as well as the cross or asterisk, or it may—in the case of a special bolt—simply bear a part number or the letters 'SPEC.'

Unfortunately, there's no industry standard for head markings. Your best assurance of getting AN-quality hardware is to *know your supplier*. This is especially important nowadays, with all the bogus fasteners floating around (see box).

AN bolts generally have class-3 (medium fit) threads and a .006-in. light-drive fit in the AN10 size (proportional up or down for other sizes). Threads may be coarse or fine (coarse being 20 turns per inch for AN4; fine being 28-pitch for AN4). The AN bolt's light-drive fit is well suited to most aircraft uses, but there are often occasions where a tight-drive fit is desirable—in which case, a *close-tolerance* bolt is called for. Close-tolerance bolts may either be AN173-AN186, or they may be NAS. Some NAS and MS bolts are ultra-high tensile strength (160,000 psi and over), for use in tension applications; you can generally tell these apart by price, and by the fact that the head end is internally wrenching.

The majority of bolts you'll work with will be AN-standard bolts, which have a logical numbering system as follows: The AN number corresponds to the shank *diameter* in sixteenths of an inch (AN4 being a quarter-inch bolt, AN5 being 5/16, etc.); whereas the dash number corresponds to the shank *length* in *eighths* of an inch (AN4-7 being a 7/8-inch-long bolt). How can you keep from confusing eighths with sixteenths? Easy. The shank diameter is always small in relation to the bolt's length, so a much finer size gradation is called for, which is why diameters are specified in sixteenths. It's unnecessary to manufacture bolts in length categories finer than an eighth of an inch, because washers can easily be used to take up sixteenths of working (grip) length as needed. Just remember, AN4 means a quarter-inch bolt, not half-inch.

Incidentally, you'll never see an 8 or a 9 in a dash number (such as AN4-8), for the simple reason that bolts longer than an inch are identified with a two-digit dash number, where the first digit is the number of inches. Thus, a quarter-inch bolt that's two and a half inches long would be designated AN4-24.

Nut Lore

Actually, bolt nomenclature reflects nut usage to a certain extent, because it's necessary to distinguish a bolt that is drilled (in anticipation of a cotter pin) from one that is undrilled (and therefore uses a locknut). In aircraft usage, bolts are assumed to be drilled—in the threaded portion of the shank (not the head)—unless otherwise specified. In other words, if you ask your A&P for an AN4-14 bolt, you're going to get a quarter-incher, one and a half inches in reach, drilled for safetying with a cotter pin. If you want an undrilled bolt, add an 'A' to the dash number: e.g., AN4-14A. (Head-drilled AN bolts—for use in blind holes, where safetying must be done at the head end, for example in certain Cleveland brake calipers—are designated with an 'H' in the primary AN number: e.g., AN4H-14A is head-drilled for safety-wire, but has an undrilled shank.)

In terms of nuts, most of the time you're going to be dealing with an AN310 (ordinary or large) castle nut or an AN320 (thin, shear-type) castle nut, both made of steel. In the engine compartment, you'll also see a few plain and light hex nuts (AN315 and AN340; and their coarse-threaded counterparts, AN 335 and AN345) with no provisions for safetying. The castle nuts are castellated, of course, for use with cotter pins. Cotter pins are used because FAA requires that all nuts and bolts in primary structures be externally secured with a safety device. The cotter pin (or cotter key) is that safety device.

In some cases, where the bolt is *not subject to rotation*, a self-locking nut (or locknut) may be used on an undrilled bolt. (Locknuts are not to be used on drilled bolts.) Elastic-insert locknuts come in thin (AN364) and thick (AN365) styles. There's also an all-steel (AN363) locknut, which is generally used in high-temperature applications—such as wheel assemblies—where it's likely the nylon insert of an AN364, say, would relax due to the heat.

The main things to know about elastic-insert (or fiber) locknuts is that the soft nylon locking feature—while resistant to common solvents such as gasoline, hydraulic fluid, Varsol, and carbon tet—can and will wear out with repeated retorquings. FAA says that when you can easily turn a nylon locknut onto the bolt tip with your fingers, it (the nut) should be trash-canned at once and replaced with a fresh one.

As mentioned earlier, locknutted bolts are not designed for use in places where they are subjected to turning forces (as in landing gear torque knees and control arms). Until 1979, though, Cessna was putting fiber locknuts on throttle-arm connections in single-engine models such as the 150, 172, and 182. Since then, Cessna has gone to castle nuts in control connections. You might check your own engine compartment to see what you've got. Rotating bolts need castle nuts and cotter pins.

For the ultimate in safety, there's actually a *self-locking castle nut* (MS17825) incorporating the best of both worlds. These are sometimes used in primary control systems.

Nuts have dash numbers, just as do bolts, but here the rule to remember is: A nut's dash number corresponds to the shank diameter of the bolt it's designed to fit. That is, an AN310-5 castle nut is designed to fit an AN5 bolt. Since there are coarse as well as fine threads to deal with, it's not uncommon to see a thread designation tagged onto the end of the nut's dash number as well. If you're working with a 5/16 bolt that has 24 turns of thread per inch, you'll want an AN310-524 nut (to give one example). If all you tell your mechanic is that you need an AN310-5 nut, he may well give you an AN310-518 when what you need is a -524. So be specific. Add the extra thread numbers and you'll eliminate any ambiguity as to the nut's intended application.

Washer Lore

Some other numbers you should commit to memory are AN960 and AN970. These correspond to small-bearing-area and large-bearing-area flat washers (which in turn are available in thin and thick styles). The latter is used mainly on wooden structures, to spread the load and prevent crushing of the underlying material. Most of the time, you'll use AN960 plain washers—one under the nut, and one under the bolt head. The dash-numbering is the same as for nuts, in that an AN960-5 washer is designed to go on an AN5 bolt. Thin washers are tagged with a suffix 'L': AN960-5L. Why different thicknesses? For one thing, it may be necessary to adjust the effective grip length of the bolt to accommodate the nut properly. (A bolt should go all the way through the end of the nut, showing at least a full turn of threads, with the nut installed. Also, the nut should

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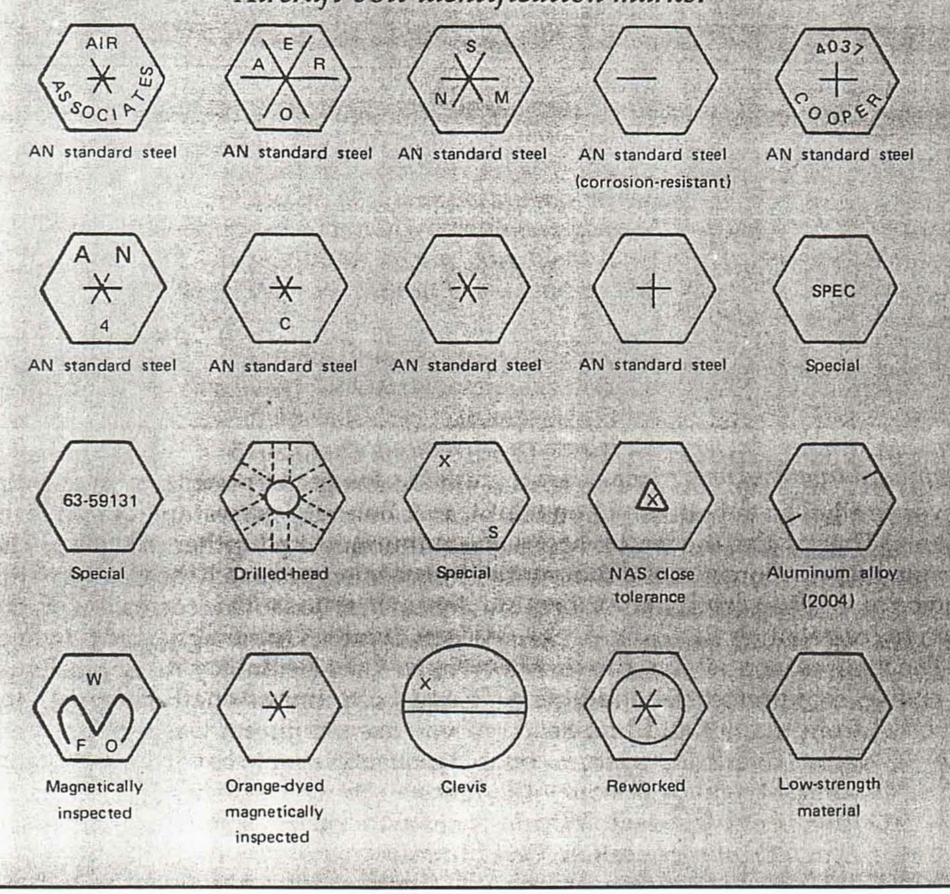
Aircraft bolt identification marks.



Beware of Bogus Hardware

Some years ago, I spent an afternoon helping put together a prototype gyrocopter kit at Ken Brock Manufacturing (a well-known supplier of parts for the homebuilt community, based in southern California). In about three hours' time, we stumbled upon three defective pieces of AN hardware. One was a clevis bolt with no slot in the head; another was an AN4-33A with no threads. We laughed these first two off as harmless curiosities, since their lack of certain essential features made it impossible that they would ever be used in a flying aircraft. The third one wasn't so funny. We had inserted an inch-long clevis into the control system, nutted it, and were in the process of trying to achieve cotter-pin lineup when it became clear that something was wrong. After trying two different castle nuts, it became clear that the cotter pin wasn't going to line up with the castellations. The bolt's hole was off-center.

Episodes like this are common throughout the industry now. (FAA received reports last fall of a batch of AN363-1032 nuts with a double-G stamped on the side having "little or no grip"; see A.D. Outlook, *LPM*, Jan. '88.) It's why manufacturers like Cessna and Piper require shops to purchase structural bolts (such as Cherokee wing bolts and Conquest tail bolts) from the factory, rather than AN hardware suppliers, often at a cost of $5 or $10 per bolt. Manufacturers, cognizant of the bogus-hardware problem, have instituted their own QA measures to insure that aircraft-quality hardware *really is* aircraft-quality.

A good example of the high cost of insuring quality in fasteners is the Cleveland P/N 40-135A wheel situation. Breakage of AN5-32A tie-bolts has been a problem in Cessna 400-series (and 340A) twins using the 40-135A wheel. As a result, Cleveland in 1986 went to a higher-strength "special bolt," Parker P/N 103-24200, for this wheel. The new bolt is actually an off-the-shelf item, MS21250-05044. But by the time Parker-Hannifin and Cessna get done inspecting it, the bolt costs $13.26 through the Cessna parts system. (A corresponding nut costs $6.90; washers are 98 cents.) Each main wheel uses nine of the bolts/nuts/washers. Altogether that's $380.52 to replace the existing AN5 tie-bolts in a 400 Cessna's main wheels. (For details, see Parker Product Reference Memo No. 41 and/or Cessna MEB87-5.)

Part of the problem is that substandard hardware is very hard to trace. Fasteners are sold most often by the pound, and individual pieces carry no paperwork. The fasteners may go through several middlemen (distributors, OEMs, dealers) before arriving at the FBO or catalog house. Along the way, bogus parts (whether harmless blanks or actual rejects from offshore sources) can easily be mixed in to "bulk up" a large order. By the time the duds are spotted, the perpetrators are—for all intents—untraceable.

The moral is: Don't take anything for granted. Perform your own "incoming inspection" on AN hardware, and expect to find some rejects now and then.—*KT*

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never be allowed to bottom out on the shank.) There's also the matter of cotter-pin line-up. Sometimes a different choice of washer can make or break the pin/castellation fit.

The main reason washers are used, of course, is to protect the underlying material from the nut and bolt-head, which might overload, gouge, or cause dissimilar-metal corrosion with the structure being fastened. Which brings up an interesting question: Do you match the washer's material to the underlying component, or to the nut and bolt? (Washers are available in aluminum and other metals.) The answer is, you match the washer to the structure, to avoid corrosion of the structure. On magnesium wheel halves, for instance, you use steel nuts and bolts (for strength reasons), but you use aluminum washers, not steel washers. Better to have a little galvanic action between washer and bolt-head than to let the soft wheel rim itself decay.

Incidentally, AN-grade lockwashers (of various sorts) are commonly available, but FAA prohibits their use in primary structures or structures subject to frequent removal because the locking features often affect torque values and/or cause damage to soft metals.

Locking washers shouldn't be needed in most of the subsystems you're likely to work on (and where they are, such as on battery posts, you'll still want to protect underlying structures with a plain washer). Cotter pins and safety wire, not lockwashers, are your first line of defense against fastener loosening.

Miscellany

Good practice, as we've seen, is to avoid using self-locking nuts on bolts that turn. Good practice also calls for the installation of bolts with the head end up (where the bolt-hole is vertical, or nearly so), to prevent the bolt's falling out in case the nut should ever come free on its own. Unfortunately, this time-honored rule of thumb has gotten some people—Seneca operators in particular—in trouble. In the Seneca's nose-gear mechanism, there is a perfectly vertical bolt that *must* be installed head-down (according to the Piper shop manual). Installing this bolt head-topside in accordance with "good operating practice" has caused more than one Seneca to land nose-wheel-up. (The tale is also told of the North American F-86's aileron system having a head-down bolt in it, with clearance problems resulting when Air Force mechanics—thinking they were only doing their duty—mistakenly reinstalled the bolts head-end up against North American's express prohibition.) Check your service manual carefully before inverting any head-down bolts you find in your aircraft. It sometimes turns out that head-down bolts were designed to go that way.

For more information on aircraft hardware, consult FAA's AC 65-9A or AC 43.13-1A, or contact any of the fastener suppliers who advertise in Trade-A-Plane. And remember to consult your aircraft (or engine) service manual before torquing any nut or bolt. The manufacturers often include a table of recommended torques (to be used as a general guide when more specific information is not given) in the front or back of the manual.