Awww Nuts (and Other Fasteners)

By Bob Lacivita — as seen in the September 2002 issue of CBR (Classic Bike Rider Magazine).

In my 35 years as a master automotive technician, instructor of automotive technology, and consultant to various publications, I truly have come to appreciate the importance of the little things that hold our big boy toys together. In my auto technology class, I devote an entire semester to teaching the proper installation, sizing and repairing of fasteners. Why so much time devoted to something seemingly so simple? Because a fastener failure can be pretty annoying or have some nasty consequences. If you've ever had a part that just won't stay put no matter what you did, then this is an article you need to read.

First, some history: The first mass-produced standardized fasteners were Whitworth designs. Before 1841, when Joseph Whitworth proposed and defined a uniformed standard of thread pitch (the distance from one hill on a thread to the next), thread depth (the distance from the top of the thread to the bottom), and thread shape (the angle between the threads), anyone who needed a threaded fastener just made one up of their own design. With the industrial revolution getting underway, and its need for interchangeable parts, this anything-goes practice no longer worked. Whitworth brought uniformity and standardization to fasteners.

Although the original Whitworth specs were designed to hold honking-big locomotives together, they loosened easily under vibration and so were of limited use on motorcycles and autos. Over the next 100 years, the Whitworth went through many evolutions and was still in limited use into the late 1960's. That's when the Brits finally joined the rest of the civilized world and began using metrics. In the USA, though, we still hang on to the US Standard (Unified Fine – UNF, and Unified Coarse – UNC) sizes.

From history, let's go to physics. Without getting too technical, a nut and bolt make up a simple machine: the nut moves up and down the bolt threads when force (torque) is applied. This force creates friction between the threads of the fasteners and it stretches or compresses the bolt (all metals are elastic) as it's rotated, generating tension (preload). "Preload" is what you call this tension between fasteners, and it's what actually keeps parts together. Obviously, the more a fastener is tightened, the greater the tension on the threads becomes. Sufficient preload is essential for a strong and reliable bolted joint, but if you overdo it, the joint fails before the fastener actually breaks. It's a delicate balancing act to get just enough tension to keep everything from flying apart, and this is why you're supposed to pay attention to torque charts and what your torque wrench is telling you.

Threaded fasteners work by stretching when tightened. Tests show that a bolt stretched to 50-60% of its "elastic limit" produces the right amount of force to create a secure joint. Under normal conditions, a bolt that's never been stretched beyond its elastic limit can be reused because it will always return to its original length when the nut is loosened. But how do you know this, since you can't tell just by eyeballing the stupid thing? Basically, you can't, which is why fasteners in critical or extremely high-stress areas shouldn't get reused.

A Bolt By Any Other Name

Okay, enough techno-babble; now let's talk about the fasteners themselves. What do you use, and how can you tell which ones you need from the hundreds of choices? The world of fasteners has its own lingo and I could write a book on this subject (soon to be on Bestseller lists, I'm sure), but from the Average Joe's standpoint, there are only three questions you want answered: (1) Why are there so types to choose from, (2) Which ones do I use and (3) What the heck do all those markings on a bolt's head mean anyhow? Bear with me as I walk you through the explanations and get you oriented.

Most fasteners are identified by size (diameter and length), strength (sometimes called "hardness") of the metal used, head style and finish. All of this information is based on various official engineering standards that should ensure uniformity.

Bolt strength is identified by a grade number (its tensile strength) and is shown by the number of lines on the head of US bolts, while metric fasteners use a number to indicate the same thing. Among the people who sell these things, a "bolt" is actually mild steel and grade 2, the wimpiest grade, with anything stronger referred to as a "cap screw." This fastener grading system has some quirks. For example, there isn't any "grade 1" plus there are other gaps in the series. Grades 2, 5 and 8 are what you'll find in US fasteners, while metrics will be available in 8.8, 10.9 and 12.9 grades. There are actually higher grade, aerospace quality fasteners, but even if you could afford them, there's no reason to use them.

Most hardware stores and home centers stock the softer stuff, grades 2 and 5 (US) or 8.8 and 10.9 grade metric. For most non-critical/non-structural applications such as mounting a fender or accessory, it's okay to use the softer, hardware store grade fasteners. For the really important and critical stuff where you can't afford to have problems, then you want the best, which means Grade 8 US or 12.9 metric hardware.

How can you tell what's what? US bolts will have lines on their head indicating their grade, with a grade 8 having 6 lines; a grade 5 has 3 lines and a grade 2 will have no lines at all. For metric bolts, look for a number on the head that corresponds to the grade, either 8.8, 10.9 or 12.9.

While in our two-wheeled world you don't want to use stuff that's too weak (grade 2 US or grade 8.8 metric) for the important stuff, but these same low-grade fasteners are adequate for a lot of things that aren't under a lot of stress—sidepanels, fenders, and things like that. For critical components like engine mounts, internal assemblies or high-stress applications, you need the good stuff. Get to know your parts person at your local auto supply store or bike dealer, as they stock these high-grade fasteners or can order them. You can also contact one of the specialty fastener sources that cater to the bike crowd. See the sidebar for a list.

Now that you know where to do your shopping, what sizes do you get? We've all heard the commercial, ". . . the 3/4 inch bolts are in the drawer marked 3/4 inch bolts." So what does 3/4 inch mean? If you bother to measure, you soon find out it's not the size of the bolt head. Nope, it's the diameter of the bolt shaft or the outside diameter of the bolt threads. (By the way, an old mechanic's trick to quickly find a bolt's diameter is to find out which size open-end wrench slips over the bolt's shaft.)

Next up on the fastener size menu is thread pitch, otherwise known as TPI (threads per inch) for US fasteners and "millimeters per thread" for metric. To determine the thread pitch of a fastener you'll need to buy a thread gauge (a few dollars at most hardware stores). And of course, just to keep things confusing, besides metric thread sizes, there are two USA TPI sizes: NC (National Course) and NF (National Fine). Get a thread gauge that measures everything. Just open up the gauge fingers until you find one that fits exactly into the threads of the fastener—that'll tell you the thread TPI or metric count.

Bolt length is simple enough: measure from the underside of the bolt head to the end of the threads. (Screws and some other fasteners are measured differently, and rather than confuse you more than we have to, we'll punt on the full explanation.)

Now a pop quiz to see if any of this stuff has stuck. At the store you'll see something like this on the label or the drawer: 1/2-13NC X 1-3/4. This means you have a 1/2-inch diameter bolt, with 13 threads per inch, with a National Coarse thread pattern, that's 1-3/4 of an inch long. Or, 12-1.75 X 25 means you have a bolt that's 12mm in diameter, with a thread pitch of 1.75mm and the whole shebang is 25mm long. The final factoid is what grade it is, based on the number or number of lines on the bolt head (none, 3 or 6 for US; 8.8, 10.9 or 12.9 for metric).

The Whole Nut

Finding the right bolt is just half the job, because now you need to find the matching nut. Nuts are measured and graded the same as bolts, with its size determined by inside diameter. The nut's grade is identified by small dots (US) or numbers (metric) on one side of the nut. For the fastener to work the way it's designed, you must match the same grade nut with the bolt it's going to be wedded to—that means using a grade 5 nut with a grade 5 bolt. If you use a lower grade nut with a higher-grade bolt, you may be asking for problems if you're bolting up something you positively don't want going wrong. Since the bolt can withstand greater torque load than the nut, the bolt can literally pull the threads right out of the nut! This is something I have my students prove to themselves in class, and it's fun to watch them yank the treads clear out of that poor little nut.

The next thing you may notice when fastener shopping is that the bolt head is often a different wrench size than the nut. Isn't supposed to be, so try and have them match, as it's a rule of thumb test as to whether you're mating up the right fasteners. This isn't gospel however, so make it a goal but not a religious cause.

No Mo' Vibes

So what keeps a fastener from vibrating loose during normal wear and tear? For years, lock washers (also called spilt or spring washers) were used to lock a nut in place and keep it from loosening. You've probably got a ton of 'em lying around. Our advice is to give them away to your worst enemy, or to your teenager to use as earrings, as they're useless for keeping mechanical things stuck together. No vehicle manufacturer has used lock washers for decades because they don't do squat.

What you want to use are what most of us call "lock nuts" or Nyloc (a trademarked brand name). There's also something called a "prevailing torque" nut, a type of self-locking nut where the last two or three threads are egg-shaped. The intentional deforming of these threads lets the nut bite into the bolt threads, increasing the preload and keeping the nut from loosening. These nuts also hold their torque setting, or are supposed to.

NyLoc nuts have a soft nylon collar inside the nut that grabs the thread of the bolt, increasing the preload on the threads, locking it into place. Because nylon can melt, NyLoc nuts aren't the hot setup (sorry) for exhaust systems.

A question that keeps coming up is how many times can you reuse a NyLoc or lock nut. According to Bill Eccles at Bolt Science Technologies there's no absolute answer and industry standards don't specify the number of reuses allowed. From my usually sad past experience, NyLocs can be ineffective after being undone just a couple times, so the Lacivita Rule of All-Thumbs is: when in doubt, throw it out and use a new one!

A flaw of most lock nuts is that because they are longer than a regular nut, the bolt may not have enough threads to fully engage the nylon or the last two or three egg-shaped threads of a self-locking nut. This is called "short bolting" because the threads of a bolt don't stick out through the nut. What can make this situation dangerous is the first few threads of a bolt or stud are chamfered to make threading a nut onto the bolt easier, which means they don't lock onto the fastener as tight. You always want at least two or three threads sticking out beyond the nut. So if you're using Nyloc or other self-locking nuts, you may need to use a longer bolt as well.

Thread locking liquids are the preferred choice for solving and preventing vibration loosening problems. The tech term for this stuff is" liquid anaerobic fastening sealers" which means they dry and harden in the absence of air. According to Loctite, thread lockers will work in a wide temperature range between -65 to 300 degrees F, provided—and this is important so pay attention—they have to be installed on a clean, dry stud or bolt. Depending on the type used, shear strength (how difficult it is to remove a fastener) ranges from a mere 1000 PSI to a super-hero defying 3000 PSI. With 3000 PSI of shear strength, you'll have to use a torch on the bolt to melt the sealer so you can remove it.

Other Stuff You Need To Know

Anti-seize compound is another tool to put in your fastener toolbox. Use this silvery, sticky stuff in high temperatures applications, exhaust systems for example, and to protects threads and other parts that need to move or slide even when subjected to a lot of corrosive situations.

By the way, avoid using a grinder's wire wheel to clean the threads of crusty used fasteners. Yes, it's a quick and convenient, but a high-speed wire wheel will also remove the hardened finish or protective coatings leaving it vulnerable to the elements.

You probably don't give flat washers a thought, but you should. Always use a flat washer having the same size diameter as the fastener it's going to be used on: for example, use a 3/8" washer on a 3/8" stud. Furthermore, always use the strongest (hardest) washer possible. Under high preloads, a soft washer can compress and deform causing preload loss (and the fastener vibrating loose). Bet you never thought the junky washer was what was making things fall off. A hardened washer also helps distribute fastener preload over a greater area, with less galling to the finished contact area. Today, flange head fasteners are routinely used rather than separate flat washers, so if you can find what you need with the flanged head, that's the way to go.

Let's Get Tight

When doing your final tightening in a nut and bolt set-up, tighten the nut instead of the bolt. Doing it this way decreases the amount the threads stretch inside the nut, while increasing the tension on the bolt, which is what you want.

Of course there's a right and wrong way to bolting things together and we figure you'd prefer to hear about the right way. Dirty, corroded, dry, uncoated or unlubricated fastener threads increase installation friction—they fake you out—to the point where things are never correctly tightened even when using a torque wrench. Torquing dirty fasteners is a waste of time, so clean and lubricate all fasteners before installing them.

Likewise, invest in and use a decent “click” style torque wrench. They cost about $70 for either a 3/8 or 1/2-inch drive models, and you’ll use it for a lifetime, so it’s money well spent. Read the instructions carefully, as there’s a right way to using a torque wrench.

The one thing I tell my students I can’t teach is “feel.” You only acquire it by experience, usually bad. If you feel a fastener begin to bind or twist, there’s something wrong. Stop immediately and see what the problem is. Trust me, it’ll only take one or two broken chain adjuster bolts stuck inside a swingarm, to convince you to start using a torque wrench on clean, lubricated threads.

Finally, there’s an old saying that goes: all small bolts are over-torqued (and eventually break), while all big bolts are under-torqued (and eventually loosen). The trick is to use a generic torque chart, or if possible, locate a service manual for the vehicle your working on. Having the correct torque for all the nuts and bolts on your project means less time dealing with fastener headaches and having more time on the road.