technically speaking

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FASTENER FACTS & FICTION

How To Select Them and How To Apply Them

Each year the fastener industry uses over two million tons of steel to produce more than 200 billion fasteners in over two million different shapes and sizes.

Prior to 1993, horror stories involving counterfeit fasteners were commonplace. The Defense Department's Logistic Agency found that 29% of its inventory of Grade 8 bolts was actually counterfeit. One major manufacturer of Class 8 trucks recalled 500 new trucks when it identified substandard fasteners in the pitman arm on the steering assembly. The Army has 1,220 of its M-60 tanks out of service because of substandard fasteners.

Some unscrupulous manufacturers use boron steel and mark it as a more valuable alloy (Grade 8 material). Also, bolts that are marked 8 are in fact made of Grade 5 carbon steel; an inferior material compared to the Grade 8 alloys. Furthermore, some offshore manufacturers do not properly heat treat the bolts. Some of these alloy steel bolts have been found to be 20% to 30% weaker that the U.S. Grade 8 standards.

These occurrences forced the passage of The Fastener Quality Act, a law aimed at counterfeit fasteners. The law requires accountability, responsibility, and traceability for all fasteners sold in compliance with the law.

Congress recognized that the fastener industry has made major improvement in its manufacturing and quality control systems and passed a simpler, more focused Fastener Quality Act in June, 1999. The new Act limits coverage to only high-strength fasteners, encourages the use of recognized industry quality assurance systems, and streamlines paperwork reporting by allowing companies to transmit and store reports electronically.

The astute fleet maintenance manager insures that his or her mechanics have a thorough knowledge of fastener principles. Let's look at some of the essentials of fasteners, then we can lay down some rules for the mechanics and service technicians to use in their repair and rebuild functions.

The threaded fastener's function is to apply a compressive load on the connection that resists opposing static, tensile and dynamic loads. Once in the connection, the fastener must resist impact, shock, vibration, shear, bend, torque, and vector forces, as well as other compressive loads. The fastener's goal is to hold materials together safely and for the duration of the expected service life of the assembly. To obtain this required clamping force while resisting all of these external forces, the fastener must be physically stretched.

Think of a bolt as a spring. Any load applied in tension will cause it to stretch. As with a spring, the farther it is stretched, the more opposing resistance is encountered, which relates in terms of clamping force. It is the desire of the steel to return to its original "at rest" position that provides this clamping force.

To better understand this nut and bolt relationship, it is necessary to identify some of the terms:

- **Yield Strength -** The point at which permanent elongation occurs in the bolt.
- **Tensile Point -** That point after the bolt as entered the plastic range at which it will break.
- **Proof Load -** The maximum safe load that can be applied to a bolt without inducing permanent deformation.
- **Pre-Load -** Twisting effort applied to the connection by stretching the fastener to a certain torque value.
- **Torque -** The amount of twisting force expressed in inch-pounds or foot-pounds applied to a nut or head of a bolt. Twelve inch-pounds or one foot-pound of torque would be created by exerting a one pound pull on a point of a wrench exactly 12 inches from the center of the bolt.
- **Grading Standards -** Four engineering groups - Society of Automotive Engineers (SAE), American Society of Testing and Materials (ASTM), International Standards Organization (ISO), and the Industrial Fastener Institute (IFI) - have a uniform method of identifying various grades of fasteners (Grade 1 through 12.9). They also establish the minimum strength requirements, chemical analysis of steel, and degree of heat treatment.

Major Reasons For Nut and Bolt Failures

A common reason for fastener failure is the use of a grade of bolt which is too low for the application. If two members were clamped together with a 1/2 inch diameter Grade 5 bolt, the minimum yield strength of that bolt would be 13,055 pounds and the tensile strength would be 17,030 pounds. If this particular connection is exposed to a service load of 15,000 pounds, the moment the load value exceeds the yield point of 13,500 pounds the bolt will stretch and stay stretched. When the load is removed, you end up with a loose nut. Going to a higher-grade bolt or a larger diameter bolt can increase yield strength. About 10% more clamping force can be accomplished by also going to finer threads.

Use of mismatched fastener components - bolts, nuts, and washers - is the second reason for failures. The nut must be the same grade as the bolt. If a Grade 2 nut is attached to a Grade 8 bolt, the nut will fail before sufficient torque can be applied to the nut to create the required clamping force. The same rule applies to the washer. Wrought flat washers are often used, but they are dead soft. If used in conjunction with a high strength bolt and matching nut, it will be impossible to achieve and maintain the desired amount of pre-load upon the connection. The wrought flat washer will compress as the bolt is being placed in tension.

Burrs and sharp edges found at the drilled hole can also play havoc with the fastener. A properly designed bolt or cap screw will have a radius fillet between the shank of the bolt and the washer face under the head. This radius helps to evenly distribute the loads of the bolt across the head and to reduce stress concentrations. Drilling a hole into a piece of steel will often leave sharp metallic burrs around the edge of the hole. Contact of the burr into the fillet will induce a stress concentration at the point of the scratch. This situation can be corrected by countersinking or chamfering the hole, or drilling a larger hole. An oversize of 1/32 inch to 1/16 inch is acceptable.

A fifth cause of fastener failure involves the use of a cap screw of improper length. When a cap screw is tightened, the stress forces holding the clamped pieces together are between the bearing surface of the nut and the washer face under the head of the cap screw. This is the "grip" area. If a fastener's length is such that, after the nut is properly tightened, only one or two unengaged threads are present in the grip area, the amount of stretch the fastener experiences, either during loading or from external impact loads, would have to be absorbed by the unengaged threads with the grip area.

These threads act as shock absorbers. If, instead, a shorter cap screw is selected for the same application, which still permits full thread engagement of the nut, a greater number of unengaged threads are now contained in the grip area. Stress on each thread is now much less, thus increasing the service life of that fastener and connection.

Impact wrenches can be the culprits of short fastener life. A nut rotating at full output RPM of the wrench comes to a very sudden stop as it contacts the work surface. This impacts an immediate torsional twist to the fastener that can cause premature failure of the fastener and the assembly. The only "safe" time to use an impact wrench is after the nut is firmly seated against the work surface. This can be done with a hand wrench, rotating the nut by hand or slowly running the nut up the threads with the power wrench. This reduces immediate impact damage.

Using rusted bolts is still another reason for failure of a clamping assembly. The rust attacks the hardest part of a bolt and can lead to false torque readings.

Tips to Make the Perfect Clamp

What can the service technician do to lengthen fastener life and avoid clamping connections from working loose? Here are some rules to consider:

1. Watch that oil spray can when tightening fasteners. Torque value tables are always given based on dry fastener components. Bolts that are lubricated can affect torque values up to 35%.

Mechanics should lubricate all fasteners with a known lubricant, then use lower torque values to reflect the use of that lubricant.

2. In critical situations, don't reuse bolts and nuts. This is especially true when reusing nuts. There is a loss of clamping force when using the old nut. Used bolts that may have "yielded" can still look acceptable.

3. Always replace a nut, bolt and washer with one of equal or even a higher-grade fastener than the one removed.

4. Watch the use of imported fasteners. They may not use the same identification grading system found on domestic fasteners.

5. Never mix fasteners components. If you are using Grade 8 bolts, then the nuts should be Grade 8 and the washers should be hardened and heat-treated.

6. Know the value of proper torqueing. Consult a torque value chart for selecting fasteners. Then use a properly calibrated torque wrench during installation. On trucks, trailers and tractors, there are many applications that require re-torqueing - spring hangars, wheel lugs, mounting bolts. Etc.

7. Don't sacrifice quality when selecting fasteners. The service life and performance of a nut and bolt is determined by three factors: quality, use of the correct grade for the application, and, last but not least, installation.