

The Bolt Doctor

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by:

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*A new re-occurring feature in **Fastener Technology International**, the "Bolt Doctor" offers distributors and users of fasteners the diagnostic and remedial advice of **Guy T. Avellon**, who has been a fastener consultant for over 25 years for fastener engineering applications, failure analysis, quality systems evaluation and product liability litigation. Avellon has presented numerous training lectures on fastener safety, assembly techniques and preventive maintenance to amusement parks, manufacturing, fleets, NASCAR teams and maintenance organizations. A member of the **Society of Automotive Engineers (SAE)**, Vice Chairman of the **ASTM F16 Fastener Committee** and Chairman of **ASTM F16.01 Fastener Test Methods**, Avellon is the founder of **GT Technical Consultants**.*

Fastener Maintenance: Specifying the Correct Fastener

Common nuts and bolts (or fasteners) are regarded as commodity items that are a nuisance to procure and keep stocked. Yet a US\$0.50 nut or bolt can cause tens of thousands of dollars in damage and lost downtime. Even worse would be the millions of dollars in liability damages from personal injury.

Maintenance and repair operations (MRO) need fasteners for a variety of equipment and facility needs. Maintenance budgets will spend thousands of dollars each year on fasteners. Where are they all being used? Why so many? Are the fasteners of poor quality?

In reality, any given strength (grade) or diameter of fastener can and will fail if not properly installed. Factors affecting installation can vary from the equipment being repaired and its age to the installation technique being used. But the greatest factor is ensuring the correct fastener is purchased to meet the needs of maintenance.

Procurement

There must be complete communication between Plant Engineering, Maintenance and Purchasing. Fastener requirements must be identified and specified to provide for

safe and cost effective repairs.

For example, maintenance is making equipment repairs requiring a bolt strength of SAE Grade 8 (150,000 psi). Purchasing is told to order 80, 1/2-13 x 5" Grade 8 bolts and 80 nuts. The Purchasing Agent seeks quotes from several sources for the Grade 8 bolts and secures a price. Almost as an after thought, nut prices are also asked. He finds that some nuts are much cheaper than others and naturally opts for the less expensive 1/2" nut. However, in this example, the reason the nut costs are so different is because they are only Grade 2 (74,000 psi) in strength.

The Purchasing Agent did not inquire about the price differences nor specify that the nut should also be Grade 8. Also, the vendor on the phone did not ask if the company needed the same grade.

There are many different strength grades of bolts and an equal number of different grades of nuts. They are designed to be mated and used together as a compatible system. Both bolts and nuts are uniquely marked to identify their strength and assure users and inspectors that the proper matching components have been used.

Having a matching system is very significant in terms of safety. If a Grade 2 nut is used with a Grade 8 bolt, the connection's strength is that of its weakest link, Grade 2. The nut will fail at the Grade 2 level as it cannot support the loads expected of the Grade 8 bolt.

When Purchasing ordered the fasteners, it was learned they were packaged in boxes of 25, so 100 were bought. Maintenance needed 80; the remainder were put into bolt and nut storage bins. This would contaminate their current inventory with 20 lower grade nuts. Now, when someone needs a couple of 1/2" nuts, they run the risk of pulling out two different grades that will be used in the same application. The safety of the connection is compromised.

Specifying

Different applications such as those involving heat exchangers, boilers and pressure vessels naturally require separate specifications. Instead of SAE fasteners, these types of applications require ASTM or ASME code fastener components (ASTM A193, B7 or SA-193, B7 for ASME, for high-temperature use, with nuts specified under A194, 2H). And both of these standards are relatively the same.

To continue the example, suppose that maintenance now needed 1/2-13 x 5" B7 bolts and 2H nuts. Having just ordered the same sized bolts, the Purchasing Agent may not notice that the grade and specification have changed. If not properly and distinctly specified, they will not receive B7 bolts or studs.

Fortunately, maintenance personnel will notice the difference between what they wanted and what was received before the parts are used. But time is lost in correcting the order and repairing the equipment to return it to service.

"The greatest factor in preventing the failure of a fastener is ensuring the correct fastener is purchased to meet the needs of maintenance."

The bolts have obvious marking differences, but studs or threaded rod stock may lose their identity if not careful. Only one end of a stud or rod is marked B7, while SAE grades may only be marked with an 8. If cut-to-length threaded rods are used, the marked end may be used and the expensive remainder could end up in stock with less expensive and lower strength materials.

Economics

All nuts and bolts look alike. It is very natural to look at two bolts and buy the less expensive bolt.

Consider two bolts; the price of one is US\$0.25 and the other is US\$0.50. One costs twice as much as the other! Assume labor costs US\$2.00 to install the bolt. It does not cost twice as much to install the US\$0.50 bolt, therefore the cost difference is between US\$2.25 and US\$2.50.

One bolt costs more than the other because it is an alloy steel bolt that is much stronger. If the weaker bolt is not strong enough for the application, it will have to fail. Failure necessitates replacement. This usually means installing another US\$0.25 bolt at US\$2.00 labor.

The bottom line is that we now have US\$4.50 into repairs of an application that is bound to fail again! This does not account for any damage to other parts the broken bolt may have caused, the cost of retrieving the broken parts, refixturing the application or cost of downtime.

There is a basic difference between price and cost. Price is what was paid for the parts. Cost includes all activities associated with the procurement and repair of the equipment. Therefore, US\$4.50 was spent on a connection that could have been done properly the first time with only US\$2.50 total cost.

The Complete System

Another commodity item rarely given much thought is the flat washer. Yet, the wrong flat washer in a critical application can cause failure. There are two types: USS and SAE. The USS washer has the larger outside and inside diameter. These should only be used with compressible materials and never with Grade 8 fasteners.

While many have used one size smaller USS washer onto a bolt to achieve a tight fit, it is too tight and may cause the head failure of stronger bolts. Unless it is kept perfectly centered during tightening, the larger ID of the USS style is too large to fully seat the underside of the hex head. The SAE washer will fully support the load of the head and should be used in all metal-to-metal Grade 5 and Grade 8 connections.

There is yet one more choice to make, and that is, to use a plain wrought washer or a hardened washer? Wrought washers are soft. This means they will compress when the bolt is tightened. Hardened washers will not.

Applying Hook's law, if the bolt head or nut were to compress into the flat washer, or work surface, enough to cause

the bolt to relax only 0.001", the bolt will lose 30,000 psi of clamping force. In other words, a 150,000 psi Grade 8 bolt will lose sufficient strength by compression-relaxation to be the equivalent of a 120,000 psi Grade 5!

The majority of flat washers will not be marked. The exception being the ASTM F436 hardened structural washers. They will be stamped "F436." Automotive OE washers used with Grade 8 bolts are hardened, but not marked.

Examine the used flat washers when disassembling a connection. If the hex head of the bolt is clearly visible as compression into the steel, or if there are visible gouge marks from turning the nut, the washer is soft and clamp load is being lost. Such a washer should be replaced with one that is hardened and the bolt should also be discarded and replaced. Lost clamping force may have created metal fatigue cracks that are not visible but will cause total bolt fracture.

Summary

Contain costs by being certain the fasteners ordered are what maintenance specified to be able to perform safely. Know what specifications are required. There are several major standards organizations (ASTM, ISO, SAE, MIL, AN, etc.) each with their own special markings for all steel and nonferrous bolts and nuts.

As one last example, there is a huge difference between ASTM F593A and F593A. The materials may be the same, but the underline denotes how the material was processed to give it unique performance characteristics. Be sure to include the underline when ordering.

All fastener markings are important. Besides the grade identification, a registered and traceable manufacturer's marking should also be present on all bolts, nuts and hardened washers.

The examples cited in this article are not entirely fictional. Miscommunication is not only internal. Correct and complete information must be communicated to the vendor for the vendor to know what is really needed to be of service to you. Vendors too should be aware of the different grades and needs of their customers.



GT Technical Consultants specializes in fastener failure analysis, training, operations improvement, quality systems and continuous improvements, technical marketing, cost reductions, fastener deproliferation, *ISO 9000* and product manual preparation and updating. Additional services offered by GT Technical Consultants include customer satisfaction metrics and analysis, process mapping and root cause analysis and calculation of torque values for any variety of grade, diameter or material bolt as well as other technical services to help add to your bottom line.