Fastener Reuse and Torque Values

by Guy Avellon

There are times when we are asked questions that we have all known the answers to from years of training and experience. But when asked "where can I find the answer printed?" we are at a loss to find the exact quote or if any such quote exists. A manufacturer or distributor should not have to answer specific technical questions because all fastening conditions and applications are unique. Misinterpretation of how the customer is going to use the fastener and under what conditions could lead to tremendous liability for both parties.

I was asked by a business associate where he could find the answer to his customer's question. I was not sure where to find the answer, so I wrote a letter of explanation to his customer. Many times, it is difficult to find answers and the answers may be in several different books or publications. Therefore, the following are several commonly asked questions about reusing fasteners and torque values.

Can a fastener be reused in a critical application?

No

This may seem like common sense but the question has been asked. One time a similar question was asked by an employee from a nuclear power facility. Realistically, there is no way of telling how much stress a fastener has endured in high stress, critical applications. The fastener may have been installed incorrectly, by stressing it just beyond its yield point or installing it way below cycling loading stresses of the application, causing metal fatigue. Since fatigue micro-cracks are not visible, except by ultrasonic or magnaflux testing, impending failure will go undetected. Fasteners are relatively inexpensive when compared with the associated liability and damage that could result. Replace it.

Can fasteners be reused under normal conditions?

Yes

This is a conditional 'yes' as it applies to steel (ferrous) fasteners that were installed under controlled conditions. The operative word here is 'controlled' because the fasteners must be installed to produce a clamp load greater than the service loads and there has been no damage to the joint surfaces, such as embedment or warping. If the conditions of use are not known, then do not take any chances: No.

Non-ferrous fasteners (stainless steel, nickel alloys, silicon bronze, titanium, etc.) will all work harden once placed under a tensile load. Here, one needs to apply discretion; if it is a small fastener, 5/16" or less, chances are it may be reused. But, once a fastener has work hardened, its mechanical properties become severely compromised.

Therefore: if any threaded fastener, ferrous or non-ferrous, has experienced any loading beyond its proof load or yield strength, that fastener should never be reused again in any application as it no longer safely represents its intended mechanical or physical properties.

Can nuts be reused?

No

This is the simple answer to a complex question. There is only one way a nut can be reused and it takes the combination of two events properly used to affect the results. So, the simple answer is 'No' since we have no idea how the nut was previously installed and under what circumstances.

The basic explanation is that the many variables of friction prohibit reuse. When the nut is tightened against the threads of the male fastener, the threads of the nut become compressed. The fastener is tightened in tension and, like the coils of a spring, the thread pitch will return to normal once the tension is released. The threads of the nut do not return to its normal pitch dimensions when unloaded. Unlike tensioning, when a material is compressed, it will remain slightly compressed, thereby permanently changing the thread pitch of the nut.

This change is usually not noticeable. That is, most likely the nut can still be freely threaded along the mating threads of the fastener. However, if one were to take hold of the nut and the hex head, and pulling both in opposite directions while loosening the nut at the same time, a grittiness between the threads can be felt as the nut is rotated off. This is extra friction caused by the thread deformation of the nut.

Therefore, when the nut is tightened again, the extra thread friction between the bolt and nut will prohibit the same amount of tightening to occur.

"But I use the same torque"

Torque is a function of friction and therefore becomes irrelevant when the nut is reused. Friction changes with each reuse as the internal threads of the nut are deflected and compressed. A torque wrench, or your elbow for that matter, sees 100% work effort. The wrench does not know how the installation friction is divided.

Tests conducted under controlled conditions have determined a new nut and fastener will consume approximately 90% work friction between the mating threads and at the nut interface when tightening. Therefore, only 10% wrenching energy is applied to tensioning the fastener after the 90% friction has been overcome. If the threads of the nut deflect enough to increase the friction between the threads by only 2% when the nut is reused, then the amount of wrenching energy available to tighten the nut decreases to 8%. The overall torque output still adds up to 100% but the fastener is tightened 2% less.

Now, the connection is not as tight as it was when first installed. Again, each time the nut is removed and reused, the thread friction increases, which decreases the amount of applied torque required to achieve proper tension.

The nut reuse phenomena becomes very critical in many applications. It is especially critical with wheel nuts since wheels are removed and replaced for tire rotations, replacements, brake inspections and repair, etc. It has been statistically found that any vehicle with over 120,000 miles is susceptible to wheel stud failure from metal fatigue because of the loss of clamp load from the wheel nuts being reused many times.

"I torqued your bolts and still get failures."

This can develop into a whole set of topics, but the main object here is to realize that printed torque values are to be used as a guide. There are so many variables involved with tightening any fastener that torque values are calculated based on the fastener's specified physical properties in the 'as produced' condition, not necessarily what actually represents the final product, joint assembly or installation method.

Take plating, for example. When torque formulas were first developed decades ago, the plating of choice was zinc. At that time, zinc plating solutions were made with a cyanide electrolyte. This was about 40-60% efficient, promoted hydrogen embrittlement and produced a rough, porous surface. Hence, the 'k' factor (commonly referred to as the coefficient of friction) was higher than the products plated with the newer non-cyanide zinc alkaline and zinc acid plating solutions in the mid 70's. These new electrolytes were over 90% efficient, reduced hydrogen embrittlement problems and produced a much smoother deposit. This changed torque values and the 'k' factor. Yet many torque value tables, and the 'k' factor, were never changed.

For decades, we have had fairly stable torque tables for plated zinc fasteners. Until now. The torque world has changed since the adoption of RoHS (Restriction of Hazardous Substances) Directive 2002/95/EC which banned the use of hexavalent chromium, Cr+6. The valence number is its oxidation state and the Cr+6 has been found to be a carcinogen. The Cr+6 has been replaced with trivalent chromium (Cr+3), a non-carcinogen coating.

The Cr+6 produced an iridescent yellow color which provided better corrosion resistance than the clear chromate conversion coatings, primarily due to its thicker coating. The Cr+3 coatings are thinner than the +6 and therefore have a much lower corrosion resistance rating in a standard comparative neutral salt spray test. To compensate, the coatings need to be thicker or have a supplemental top coat or sealer applied. The hexavalent coating was self-healing whereas the trivalent coating is not.

It is the variation with the thickness of the Cr+3 conversion coatings produced from different plating companies that is producing a wide variation in torque values on fastener products with the Cr+3 conversion coatings. Notably, recent torque experiments have shown that with many of the Cr+3 fasteners, previously stated torque values had to be increased by 7-10%.

Therefore, variations may be experienced not only from different platers, but even from how the coating is applied and to the application of different sealers used, if any. Then, when the same plating variables from the fasteners to the nuts which are also plated from different sources are combined with the plating variables, accurate torque values become scarce.

Standardizing on product sourcing, vendors and platers, can help control variables and reduce potential customer problems. ■