Knowing How a Fastener Failed will Help in Preventing Future Failures

Bolts

The primary question during any investigation is what was the strength/grade of the fastener?

This may appear to be a little too basic, but one must consider that when there are multiple fasteners in a connection it must be considered **that there could be a chance that one or more fasteners of the incorrect grade might have been used.**

Situations like this do and have occurred, primarily around large industrial plants where there are many maintenance personnel working with structures, boiler systems and general maintenance. Fasteners are usually stored in open bin containers where everyone has free access.

When workmen are in a hurry, they grab a few extra bolts in case the threads jam. The unused bolts are returned to the bin, sometimes not to the same one. That is, they could be returned to another closer storage bin with similar bolts of different grades or even in the same storage unit but with different length bolts.

There are newer structural bolts on the market offering strengths of 144 ksi and 200 ksi that need to be separated due to the intended final applications. They have their own special markings and are assemblies with one nut and two flat washers.

Heavy equipment manufacturers have used various grades and styles of bolts for their products. Some manufacturers have even opted to use proprietary strength bolts or different styles of bolts. When maintained by their customers the same grade or style of bolt cannot be found or the mechanic does not recognize the difference.

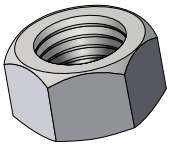
Take, for example, the bolts on the bull ring gear on a turret lift truck. A failure from using bolts of improper matching strengths would be catastrophic.

It is important to identify the grade of the failed bolt to compare that with other bolts in the connection that may have been compromised by the weakness of the failed bolt that may lead to metal fatigue in other bolts.

Socket Head Cap Screws

All inch threaded SHCS have the same strength, depending upon size, and hence are not marked. Those products equal to 0.5” and less have a tensile strength of 180 ksi, which is a little stronger than the metric 12.9. Those products larger than 0.5” have a strength of 170 ksi.

Metric SHCS on European made equipment may use different Property Class products: 8.8, 10.9, 11.9 and 12.9. These numbers are marked on either the side of the head or on the top of the head. **It is extremely important to identify the P.C. of the SHCS for proper replacement and to determine if all of the other SHCS in the connection were of the same tensile strength.**



Nuts

All nuts look alike. Structural nuts may be heavy or thick but standard maintenance nuts look identical to one another, except for their grade markings. They may be dip-and-spin coated, electroplated or galvanized or have no coating at all except for a black oil finish.

Every Standards Organization has their own unique way of marking their different grades of nuts for identification: SAE, ISO, ASTM.

The SAE (Society of Automotive Engineers) uses a system of dots and dashes to identify their Grade 2, 5 and 8 nuts. Some of the markings may be on the flat finished side or on the curved hex portion of the nut, especially with metal lock nuts.

The ISO (International Standards Organization) primarily has jurisdiction over metric fasteners. All of the metric nuts will have numbers on them which will not only identify the Property Class but the alloy composition of the nut. Standard nuts will have an 8, 10, 11 or 12. These numbers correspond with the strength of the bolt without the point after the Property Class number. For instance, a bolt may be marked '10.9' but the matching strength nut will be marked '10'.

Nonferrous alloys will have a letter and number designation. Austenitic alloys will be designated 'A' followed by their Property Class, such as 'A1-50' or 'A4-70'. Ferritic alloys are designated with a prefix 'F' and Martensitic alloys will be identified with a 'C'.

The American Society for Testing and Materials (ASTM) uses the markings '10S' and '10S3 for metric structural nuts. There shouldn't be a problem distinguishing between these carbon steel nuts with any other ISO metric nut. The most common ASTM nut used is the DH, heavy or thick, zinc coated and non-zinc coated, used for many bolt grades.

Many maintenance personnel don't either look at the markings or know what they mean. There have been several instances where one common bin held three different grades of nuts of the same size and appearance. Under normal circumstances one lower grade of nut can be substituted but not two grades lower. The nut threads may not strip during assembly but may be weakened enough to promote metal fatigue to the bolt and the adjacent bolts.

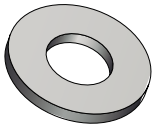
Sometimes the nut may not be found when a failure occurs. Therefore, it is important to identify the type of fracture the bolt sustained and how it may have affected the adjacent bolts so the adjacent bolts can be replaced if necessary.

Metal prevailing torque-type lock nuts have always had some type of coating on it to overcome the friction drag caused by the deflected threads. Originally, these were electro plated with cadmium, which produced a very stable and consistent torque-tension relationship with regards to its low coefficient of friction.

The government decided to ban the use of cadmium in the late 90's as it was found to be a carcinogenic. Therefore, different coating replacements were used from zinc, zinc dip coatings and nickel alloys. Each have their own coefficient of friction and affect the torque-tension relationship differently.

The problem maintenance has encountered working on machines or other equipment that used the cadmium plated lock nuts is when the cadmium nuts were replaced with standard zinc lock nuts. Again, in a multiple bolt assembly, if one or two were replaced, then tightened to the manufacturer's recommended torque values, those bolts would be underloaded because the torque for the cadmium plated nuts are lower due to the cadmium's lower coefficient of friction.

Even though the cadmium plated lock nuts had a supplemental hexavalent chromium dip that gave it a yellow/gold finish, older products in use may have lost their luster and visual identification is impossible. When maintaining older equipment and a visual mixture of gold for cadmium and silver for zinc is noted, it is best to replace all of the nuts with new prevailing torque type nuts so they may all be torqued evenly.



Washers

Many ASTM Heavy Hex Structural standards require the fastener components to be comprised of a bolt, two flat washers and a nut assemblies. The flat washers will follow the F436 / F436M Standard for through hardened steel washers. There shouldn't be any problems with preassembled units, it is where a decision is made whether or not to use washers in an application that may cause problems.

Flat washers are intended to provide a smooth load bearing surface to turn against when tightening a bolt head or nut. It may be used to cover slight oversized holes, provided the hole diameter is not larger than the washer face of the bolt or nut.

If a multiple bolt connection uses flat washers, it is important to identify if the failed bolt used a flat washer or not. In some dynamically loaded connections, the absence of a flat washer will change the length of the bolt that will reduce the amount unengaged threads in the connection. The fewer unengaged threads would mean extra stresses on those unengaged threads that would create a stress raiser in the thread root to promote metal fatigue.

Maintenance personnel have choices between hardened washers, softer plain washers and SAE versus USS.

Hardened flat washers are not usually marked outside the F436 products. Many are marked by specialty distributors. These are recommended for use with SAE Grade 5 and greater and ISO 8.8 and higher. **A plain flat washer used in high strength and dynamically loaded connections will form an imprint of the bolt head or nut into the washer. This relaxation will cause loss of clamp load and create metal fatigue.**

The SAE flat washer has an inside diameter that matches the outside diameter of the bolt with the right amount of ID tolerance. The USS washer is meant for fender bolts and softer material because the inside diameter is too large to match the washer face of the bolt or nut and will not fully support the load of a higher strength bolt.

Check the materials and size. Be consistent.