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Fastener Quality Act Information

Unbrako offers this link to the National Institute of Standards homepage on the Fastener Quality Act as an aide to individuals who need detailed and complete information on the Act. Click here to have the most detailed information on the Fastener Ouality Act at your fingertips.

Proper Tightening of Fasteners

Threaded fasteners are tightened for the obvious reason of clamping parts together and transmitting loads. In gasketed joints, the purpose is to prevent leakage. In other joints, the clamping force is developed to prevent the parts from separating or shaking loose.

The proper amount of tightening (or pre-load) is important. If the fasteners are too tight they may break - either during the tightening itself or when the working load is added to the pre-load in applications such as gasketed joints. If too loose, the fastener will shake loose in vibration. Often overlooked, but equally important, is the tendency of fasteners subjected to cyclic loading to fail from fatigue if not sufficiently tightened.

In normal joints, the clamping force should equal the working load. In gasketed joints, it should be sufficient to create a seal.

EFFECT of FRICTION

When torque is applied to a fastener it (1) overcomes friction to turn the fastener and (2) stretches the fastener - however slightly - to develop the clamping force. The latter is considered the useful part of the torque.

It has been estimated that between 50% and 80% of the applied torque is needed to overcome friction. As a result, failure will occur in the fastener before the axial strength, determined by tensile testing the fastener, can be reached.

It is evident then, that the better the lubrication on the fastener the more of the torque energy will be converted into actual clamping force.

The type of lubricant used has a definite effect on how much of the torque is needed to overcome friction. Molybdenum disulfide, wax, and white lead are good lubricants; cadmium and silver are fair, and machine oil is considered poor.

Published torque values are for average conditions. If the bolts are coated with a good lubricant, threads help maintain a more consistent torque-tension relationship. Other factors affecting friction are hardness of the material (generally, the harder it is, the less friction) and type of material (aluminum is less "sticky" than steel but more so than cast iron).

DETERMINATION of TORQUE

All fastener materials are slightly elastic and must be stretched a small amount to develop clamping force. As a rule of thumb, a stretch of .001 inch per inch length of a fastener develops about 30,000 psi clamping force in steel and 15,000 in titanium.

The best way to determine the correct torque is to run tests on the particular joint by tightening five bolts until they just begin to yield. The optimum torque is 80% of this value.

Another method is to tighten to 50% to 80% of the ultimate tensile strength on steel parts. Pre-loading to 50% to 60% of the strength of the fastener is used because of the many variables. The fastener should not be loaded above its torque yield strength, and the lower values will generally keep the loads below this point. However, the more accurate the method of controlling tightness the more of the strength of the fastener can be utilized.

METHODS for CONTROLLING TIGHTNESS

Six methods can be used to control tightness of a threaded fastener. In order of increasing accuracy - and increasing cost - they are:

Method	Accuracy	Relative Costs
Feel	+/-35%	1
Torque wrench	+/-25%	1-1/2
Turn-of-the-nut	+/-15%	3
PLI washers	+/-10%	7
Bolt elongation	+/-3-5%	15
Strain gages	+/-1%	20

But this table only tells part of the story. The less the accuracy of the tightening method the greater must be the minimum yield strength of the fastener in order to compensate for preload variations and to insure a minimum clamping force. This can be done only be using a fastener material of greater strength or increasing fastener size - both of which will increase the cost of the fastener.

The decision as to which tightening method to use depends primarily on the criticality of the joint. Generally, the more critical the joint the more need for higher tightening accuracy and the greater the cost for obtaining the right clamping force. It should always be noted that the method selected will almost always lie between the two extremes, for few applications will allow the high inaccuracy of the "feel" method, while the high cost, highly accurate strain gages are used almost entirely in the laboratory. The other methods may be summarized as follows:

TORQUE WRENCH
This is the least expensive of the accepted methods of controlling fastener preload but is the least accurate, chiefly because the reading on dial is affected by the friction to be overcome.

TURN-OF-THE-NUT
In this method, the nut or bolt is turned a predetermined number of degrees after all play has been removed from the joint.

How much to turn the nut or bolt cannot be calculated (because of the "rubberiness" of the joint) but must be developed by tests for each joint. It eliminates the friction factor; however, its accuracy is affected by the care of the workman in measuring the angle the nut or bolt is turned.

PRELOAD INDICATING WASHERS
Preload indicating (PLI) washers utilize compression of an inner ring between two flat washers with an outer indicating washer for control. As the load increases, the inner ring, which is higher than the outer one, is squeezed down and enlarged in diameter until the outer washer binds against two flat washers. When the inner ring has been flattened to this point, the correct clamping force has been reached. The PLI washer is sensitive only to axial load.

BOLT ELONGATION
In this method, a bolt from the lot is loaded in a tensile machine with the same nut as used in the application. The distance from the nut face to the underside of the bolt head is measured, and a plot is made of bolt elongation in relation to induced load. In the application, the fastener is tightened and the bolt elongation is measured until the required preload as determined from the plot has been achieved.

Not All High-Strength Fasteners Are Created Equal
To understand high-strength fasteners, it is essential to define them. For the purpose of this article, high strength fasteners are screws and bolts with more than 150,000 psi ultimate tensile strength produced for stock and manufactured in accordance with an industry consensus standard. Also, they tend to be used in applications where their unexpected failure can result in injury or expense.

One of the most common phrases used when discussing high-strength fasteners is Grade 8. Technically, it refers to the highest strength level specified by the Society of Automotive Engineers' standard SAE J429. However, the term is not always used correctly. It is frequently used to mean "the highest strength available." And, this can cause confusion. Grade 8 fasteners are not the only high-strength fasteners. Nor are they the highest strength fasteners made for stock or made in accordance with industry standards. Some headed socket screw products have strength levels comparable to or greater than strength levels of products with a Grade 8 designation.

Furthermore, Grade 8 refers to more than just strength level; it incorporates a comprehensive list of requirements. As the scope and content of SAE J429 indicates, there is a certain family of materials that must be used if fasteners are to be considered Grade 8. The chemical compositions are classified as medium carbon alloy steels. SAE J429 also specifies manufacturing, testing, and part identification requirements.

Just as Grade 8 fasteners have requirements that must be met before they earn Grade 8 designation, socket screw products also have standards. The reason for these standards is to define terminology so that communication is improved and misinterpretations are avoided.

Several standards exist for socket screws. They come from the American Society for Testing and Materials (ASTM), the American Society of Mechanical Engineers (ASME), and the American National Standards Institute (ANSI). These standards are used by most manufacturers when making inch-series socket screws for off-the- shelf inventories. And just as Grade 8 hex head means a product made in accordance with a particular standard (SAE J429), an alloy steel socket head cap screw means a part made in accordance with certain standards (ASTM A574 or ANSI B 18.3).

If products are described using references to inappropriate terms and standards, mistakes can result. For example, what would the phrase Grade 8 socket head cap screw mean? There is no "grade" designation for industry standard inch socket screw products. Each socket screw product has its own industry standard. The number assigned to the standard is the closest correlation to the SAE grade designation system.

1936-Series vs. 1960-Series

The term 1936-Series and 1960-Series are also used with socket head cap screws and can create confusion. These terms do not refer to the materials of the screw. Because the American Iron and Steel Institute (AISI) uses four-digit designations for materials, 1936 and 1960 are sometimes mistakenly thought to define screw material. These terms refer to the dates of acceptance for dimensional relationships, regardless of whether the screw material is alloy steel, stainless, steel or exotic alloy.

Summarizing the development of socket head cap screws helps to illustrate the meanings of 1936-Series and 1960-Series.

Socket screws, developed for applications with limited space, have cylindrical head and internal wrenching features that allow them to be used in locations where externally wrenched fasteners aren't desirable. Their original configuration didn't maintain consistent relationships among the nominal shank diameter, head diameter, and socket size throughout the available size range. This limited the performance potential of some sizes. In the 1950s, one socket screw manufacturer performed extensive studies to optimize performance based on geometry, fastener material strength, and typical applications. These studies resulted consistent dimensional relationships throughout the size range. Eventually, these relationships were accepted as industry standards and the year of acceptance - 1960 - was adopted to identify the optimized designs. The term 1936-Series was selected to identify the older style for replacement situations.

International and foreign standards for metric sizes

The International Standards Organization's ISO 898 contains a system of "property classes" that perform a function similar to the SAE J429 grade designations. These property classes differ in material - and have up to a 100 percent difference in strength. The two most pertinent property classes are 10.9 and 12.9.

The numerals used in property class designations refer to the nominal ultimate tensile strength and nominal percent yield strength. For example, a Property Class 10.9 fastener has a 1,000 MPa nominal ultimate strength and a yield of 90 percent of ultimate. The strength of Property Class 10.9 allows the use of plain carbon steels while Grade 8 calls for only alloy steels.

The U.S. industry standards for metric, alloy steel socket head cap screws, ASTM A574M, specifies one strength level. This strength level is equivalent to ISO 898 Property Class 12.9 and is similar to the strength level for inch socket heads. Although the U.S. standard specifies only one strength level, metric socket screws are manufactured around the world to various standards. These standards allow strength levels and materials different from the U.S. standard. Property Class 6.8 has a nominal tensile strength (600 MPa) only one half of Property Class 12.9 (1,200 MPa). Therefore, there are metric socket screws in distribution that look similar but have different strengths.

Metric socket head cap screws used in the United States are normally the 1,200-MPatype. However, recent activities of international standards committees have resulted in the acceptance of the 10.9 Property Class as a standard for socket heads. Pressure for this came mostly from the continental European delegations. This property class has lower strength than U.S.-accepted standard and may even be a different material class. The acceptance of the 10.9 Property Class means there will be a greater influx of Property Class 10.9 products in distribution, increasing the potential in the United States for inadvertent substitution.

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Conclusion and analysis
The highest strength, made-to-a-standard, off-the-shelf fasteners are inch alloy steel socket head cap screws.

Grade 8 fasteners are a lower strength level and have specific marking requirements. Making socket head cap screws which conform to the Grade 8 standards typically requires different heat treat and head stamping operations.

The user of metric socket screws must be wary of the strength level of the fasteners he or she is buying. Purchasing by the simple description metric socket head cap screw can result in one of many strength levels being received. This can result in installation problems or undesirable product performance. Metric alloy steel socket head cap screws manufactured in accordance with international standards can be different strengths and Materials.

The U.S. industry consensus standard specifies one strength level and material class. This is comparable to the strength levels and materials for inch alloy steel socket head cap Screws.

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