Run Times
LAWRENCE PUMPS INC.
Nov 2006 *vol.3_iss 11*

A bolted joint that has not been properly tightened may become loose or fail when subjected to vibration, shearing forces or impact. Use of the correct, properly lubricated, fastener on an appropriate bolting surface, and the correct bolt tension are key elements toward achieving a reliable bolted assembly.

Dale B. Andrews

Dale B. Andrews – Editor

Metal fasteners used in critical joints must be capable of withstanding the sum of the forces applied including misalignment, vibration and impact, as well as resist any pressure acting to force the joint apart. In a properly assembled joint, the fasteners are stretched, acting somewhat like very powerful springs, to resist the forces acting on the joint. Designers choose fasteners based upon the strength required to properly clamp the joint faces under the specified operating conditions.

Fasteners are available in a broad range of materials that have widely varying tensile strength properties. Misapplication of fastener materials may result in joint failure. Fig 1 and Table 1 show common industrial designations for metal fasteners*. An SAE grade 1 fastener has less than half of the tensile strength of an SAE grade 7 fastener. The fastener grades should always be verified as part of any assembly procedure.

Proper fastener application has been further complicated, in recent years, by the proliferation of counterfeit fasteners in the marketplace. A counterfeit fastener is any fastener that fails to pass strength testing appropriate to its designation. It is important to purchase fasteners from suppliers that have stringent and well documented quality programs.

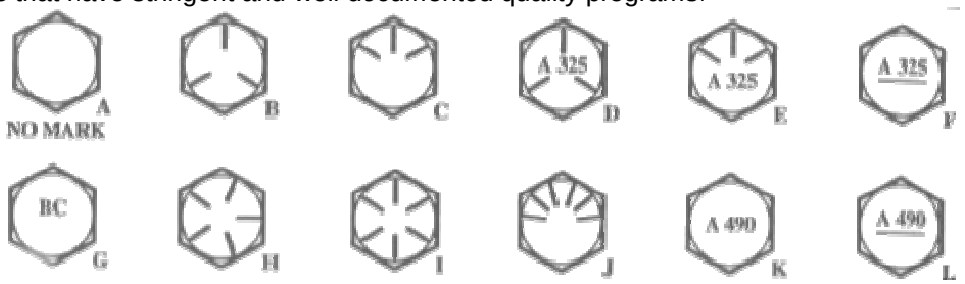


Fig 1 – Grade Identification Marks

Identifier	Grade	Identifier	Grade
A	SAE Grade 1, 2, & 4 ASTM A307	G	ASTM A354, Grade BC
B	SAE Grade 5 ASTM A449	H	SAE Grade 7
C	SAE Grade 5.2	I	SAE Grade 8 ASTM A354, Grade BD
D	ASTM A325, Type 1	J	SAE Grade 8.2
E	ASTM A325, Type 2	K	ASTM A490, Type 1
F	ASTM A325, Type 3	L	ASTM A490, Type 3

Table 1 – Fastener Grades

The condition of the fastener mating surfaces is likewise an important factor in achieving a good joint. Bolt heads and nuts should seat squarely against the surfaces that are being clamped. The surface that is in contact with the bolt head or nut should be machined. As-cast surfaces will contact the fastener seating surfaces unevenly, causing high point loads, bending, and may cause premature joint failure despite the application of proper bolt tension.

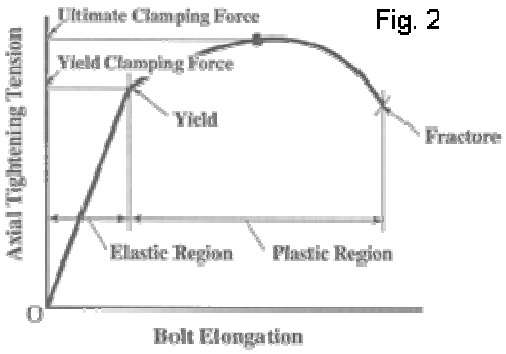
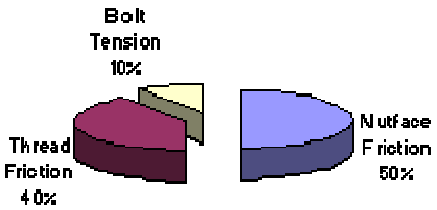


Fig. 2

Fig 2 graphically represents the strength characteristics of a bolt*. Increasing bolt tension will stretch a bolt, in a predictable linear elastic fashion, until the yield strength of the fastener is reached. After passing its yield point, further increased tension on the bolt will stretch the bolt non-elastically until the ultimate clamping force (ultimate tensile strength) is reached, after which the bolt fails.

Designers typically stipulate that fasteners be tensioned to some percentage of their yield strength so that under normal changes in joint load, the clamping strength of the joint fasteners is not lost. However, knowing what tension a fastener should have, and knowing what tension a fastener *does* have are two very different things. Fig 3 represents the typical distribution of energy applied to tighten an unlubricated fastener. Approximately 90% of the applied torque is consumed by thread friction and friction between the nut face and its seating surface**. When tensioning a fastener using a torque value provided by an equipment manufacturer, it is important to know the lubricant conditions that the torque value is based upon. Also, it is as important to lubricate the seating surfaces as it is the threads, something that is often overlooked.

Fig 3



Compounding the problem of uncertain bolt tension is the inherent inaccuracies of most tensioning methods. Use of "feel" even by an experienced craftsman is probably no better than about 35% accuracy, and feel is useless on large fasteners, simply because the energy required to properly tension the joint is beyond human capability. Impact wrenches are even worse because most users have no idea what torque is being applied to the joint. Most impact wrenches are uncalibrated, and the impact wrench's torque transmission capability, relative to its state of repair is unknown. For critical connections, impact wrenches are best suited for loosening fasteners, not for tightening them. One accurate method for verifying bolt tension is to measure bolt elongation, either with strain gages, micrometers, or special bolts that provide a visual indication of bolt tension. Using bolt elongation provides confirmation of the bolt tension value. Probably the most widely applied method of bolt tensioning is the use of torque wrenches to achieve proper bolt tension through an applied torque value. Although there is uncertainty about this method, primarily due to the friction factors, the use of published tables along with a targeted fastener stress of about 70% of yield strength, will generally allow for enough tolerance to provide a reliable joint.

In summary, use of proper materials, good mating surfaces, and lubrication in keeping with the torque values being applied are all key to achieving a proper clamping force. Equipment manufacturers can provide guidance to the proper materials, torque values and the preferred tensioning methods. It's important that fastener suppliers be reputable and that they have quality controls that validate fastener grades. Finally, but not the least important, is that a quantifiable tensioning method should be used on critical joints.

* Machinery's Handbook, 26th edition, Industrial Press – 2000
**Bolt Science Inc. http://www.boltscience.com