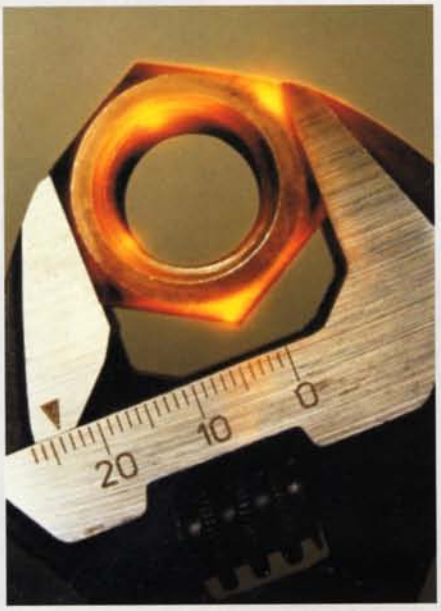
BOLT TENSIONING

The function of a fastener is to join two or more materials together. This can be accomplished by use of adhesives, rivets, rubber bands, brazing, welding, zippers Velcro, threaded fasteners, or perhaps even ducting tape. Some are only temporary and others more permanent. In this editorial we cover the most critical and most dangerous fastening device made: ***the threaded fastener.***

The primary function of a the threaded fastener is to apply a compressive load on the connection that will resist opposing static, tensile and dynamic loads such as shock, impact, vibration, shear, bend, torque, angular / vector loads as well as compressive loads. It must do this safely and for the expected service life of the assembly. To ensure a fastener performs in its application, as the engineer intended, it must be adequately tensioned



A bolt and nut are designed to act together (and sometimes in conjunction with other fasteners such as spring or flat hardened washers) - as the internal threaded fastener (ie nut) is tightened onto the externally threaded fastener (ie bolt), the bolt is forced to stretch or elongate. This stretching / elongation is maintained by the head of the bolt and the nut on the joint thereby maintaining the joint at the desired tension.

- As a rule, the joint will have been designed with sufficient fasteners to apply the required clamp load at 65% of the fastener proof load stress figure i.e. well below the fastener's yield point. (Note gaskets or soft joint components can significantly alter this)

1. Yield Point or Yield Strength

The load that is necessary to stretch the fastener to the point where, after the load is removed, the bolt will not return to its original or previous length. In other words it has now moved from being elastic to plastic in behavior.

In order for the fastener to incur a longer length part of the bolt donates material. This will come from the threads, which are the weakest part of the bolt. A section of the threaded portion of the bolt wall suffers a reduction of area and will " neck-out" creating a " dog-bone " appearance. The change in stress area makes the bolt considerably weaker and as the bolt is stretched even further the clamping load decreases. Additional stretching (caused by operator attempting to retighten the joint and fastener) will ultimately cause the bolt to break at its TENSILE POINT.

2. Tensile Strength

Is the maximum tension applied -load a fastener can support i.e. how far it will stretch prior to failure or coincident with its fracture. (Otherwise known as Ultimate Tensile Strength or UTS) Imperial is shown as pounds per sq inch (lbf/in2) or phi while metric is shown as Megapascals or MPa and the figures are quoted as a minimum

3. Clamp Load

To produce clamp load, the fastener must be placed in tension. If the fastener is not stretched then there is no clamping load. Once the bolt is clamped and firmly seated in the joint bolt tension now results from the turning of the nut along the threads of the bolt. The bolts start to stretch elastically, proportional to the amount of nut advancement. As the nut is further turned the threads of the bolt and nut are forced together under enormous pressure generating friction between the mating threads and also causing tensional twisting to the body of the bolt between the clamped surfaces. The bolt is now experiencing two forces simultaneously, tension and torsion.

In a bolted connection the bolt must be stretched sufficiently to produce static preload upon the connection that is greater than the expected external loads rather than the joint assembly acting upon the bolt themselves. These external loads must be known so that the proper grade, size, diameter, thread pitch and number of fasteners can be chosen to create a safe joint or fastening.

When selecting the proper grade of fastener, PROOF LOAD is the most important physical property of the fastener. Proof load is the MAXIMUM SAFE load that can be applied to a fastener without inducing permanent deformation, as with yield. Tensile strength, of course, is the point at which the fastener will break. The fastener must be stretched far enough to produce a predetermined amount of SAFE preload to the assembly without causing any permanent damage to the fastener.

4. Proof Load Stress or yield load stress

Proof load is the maximum safe load that can be applied to the fastener Without inducing permanent deformation. The tensile load or weight applied to a fastener, which causes the material to exceed its plastic limit.

Fasteners are generally " torqued " to 65 % of the designated proof load stress figure for that fasteners specific diameter and thread form.

5. Preload

Preload is applied to the connection by stretching the fastener to a certain torque value. Torque is the turning moment of fastener or nut, which is expressed as the product of the force exerted (pounds) and the length of the lever arm (inches or feet). Due to the many variables associated with torque a safety factor is calculated in determining a torque value, which will produce a clamp, load lower than the yield point of that fastener. The method most widely used by the fastener industry is to calculate torque at between 65%* of proof load stress figure.

6. Torque - what does it mean?

Essentially the twisting force applied to a fastener during tightening.

The torque applied to a fastener must overcome all friction before loading takes place ie 50 % of torque applied is to overcome head-bearing face friction, and 35 % is to overcome thread friction. So 85 % of torque applied is overcoming friction and 15% is available to produce bolt load .

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In further issues we will discuss in greater detail issues relating to torque, torque wrenches, effects of lubrication and many other factors that must be taken into consideration in fastener applications.

7. Means of torquing fasteners and achieving preload

Pre-Load Measuring Method	*% of Accuracy*	*Relative Cost*
Feel or Operator Judgement	+/- 35	1
Torque Wrench	+/- 25	1.5
Turn of Nut	+/- 15	3
Fastener Elongation	+/- 3 to 5	15
Strain Gauges	+/- 1	20

• Feel or Operator Judgement

The most commonly used method, which is usually satisfactory in non-critical joints where there is no vibration; there is however a tendency to over or under tightens. Only recommended in non engineered or DIY applications

How tight is Tight?

No two mechanics will tighten the same fastener to the same value using a conventional hand wrench. . One mechanic might tighten a bolt to "feel" and produce a load of 6000 lbs while another may produce a load to his " feel " at 4500 Lbs. If the bolts were mild steel (Gr2) the first mechanic would probably have over-tightened and destroyed the bolt while the second loaded it properly. If the fastener were Gr5 the first operator would have correctly loaded it whilst the second operator would have under-loaded it. And if it were a Gr8 bolt both operators would have under-loaded it.

• Torque Wrenches

Torque wrenches are the most commonly used method of tensioning fasteners because of the low cost and simplicity, however the degree of accuracy (up to +/- 25%) can be compromised due to a number of varying forces such as coatings, lubrication and surface texture.

• Turn of Nut

Commonly used in structural bolting applications, involves measuring the rotation of the nut relative to the point where the joint members were in solid contact (or "snug fit "). It is time consuming because it entails the marking of the components to measure the degree of turn. It is only recommended for coarse threads

8. Solutions and suggestions

• Tightening up fasteners using cheater bars ie pipes attached to sockets etc to give more leverage is dangerous and must not be used. It is not a contest to see who can tighten the fastener up the hardest!!!!!

• Bolts and nuts should not be reused - especially in critical situations. Whilst they probably could be reused, from a safety aspect it would be wise to err on the side of conservatism (and safety) and employ new fasteners in the application

• Understand the fasteners you plan to use, obtain proof load values, purchase a torque wrench &/ or recalibrate your equipment, take into consideration all the variables such as lubricants etc and preload the assembly correctly

• If in doubt consult an engineer