INDUSTRIAL FASTENERS INSTITUTE

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Fastener Tightening Can Be Determined by Several Methods

Calculation method of determining tightening values:

Fastener suppliers are frequently asked by their customers how much torque a given part should be tightened to in their specific application. This sounds like a very simple question that should have a simple answer, but many variables in an application influence the answer. Some of these factors include:

- What is the strength of the external thread member?
- What is the hardness of the mating threads?
- What is the hardness of the material the bolt is seating on?
- What is the length of thread engagement?
- What are the finishes on the mating threads?
- Is it a rigid or gasketed joint?

Fastener suppliers frequently ask for a chart of torque values to recommend for a given type of fastener. There are a few such charts and there is a standard formula, T=KDP, but these provide a “rule of thumb” or a “guestimate” for any given application.

T = Torque in inch pounds
D = Major diameter in inches
P = 75% of the yield strength of the bolt in pounds-force
K = Nut factor (see below)

Torque conversions:
Foot pounds = inch pounds times .0833
Nm = inch pounds times .113

A major variable in any formula used in creating torque charts is the “K” or “nut” factor. This is the factor that primarily deals with the coefficient of friction in the application. In bolting, the joining of slippery bolts and nuts requires less torque to achieve proper tightness than non-slippery parts. The “K” factors vary from .1 (very slippery) to .4 (very tacky). Below is a list of K factors for currently used fastener finishes.

Fastener Finish K Factors							
As received steel	0.18		GEOBLACK® 147	0.15		Magni 575	0.13
Black Oxide	0.20		GEOBLACK® ML	0.16		Magni 590	0.11
Cadmium plated nuts and bolts	0.19		GEOMET® 500 A	0.17		Magni 591	0.11
Copper based antiseize	0.13		GEOMET® 500 B	0.17		Magni 594	0.12
DACROBLACK® 107	0.14		GEOMET® 720 L	0.15		Never-Seize Paste	0.17
DACROBLACK® 127	0.15		GEOMET® 720 ML	0.17		Phosphate & Oil	0.18
DACROMET® 500 A	0.19		GEOMET® L	0.15		Plain	0.20
DACROMET® 500 B	0.19		GEOMET® ML	0.17		Rusty (exposed outdoors 2 wks)	0.39
DACROMET® L	0.15		GEOMET® P	0.20		SermaGard (Aluminum particles in a ceramic binder) basecoat + wax	0.23
DACROMET® ML	0.17		GEOMET® XL	0.09		Xylan 5230 (PTFE)	0.12
DACROMET® P	0.20		Graphite coatings	0.19		Zinc & Black (cr6)	0.22
DACROMET® XL	0.09		Hot dip galvanized - clean and dry	0.23		Zinc & Clear (cr6)	0.22
Delta-Protekt KL 100 base coat with Delta VH 301 topcoat	0.17		Machine Oil	0.21		Zinc & Clear (cr6) & Waxed Locknut	0.18
Delta-Protekt KL 100 base coat with Delta VH 302 topcoat	0.19		Magni 510	0.15		Zinc & Olive (cr6)	0.22
Delta-Protekt KL 100 base coat with Delta-Seal	0.23		Magni 5111	0.15		Zinc & Yellow (cr6)	0.22
Delta-Protekt KL 100 base coat with Delta-Seal GZ	0.18		Magni 515	0.15		Zinc (mechanical) & Clear (cr6)	0.35
GEOBLACK® 117	0.20		Magni 560	0.13		Zinc-Cobalt electroplated finish	0.30
GEOBLACK® 137	0.17		Magni 565	0.13		Zinc-Nickel electroplated finish	0.30
Note: Values determined using DIN 946.							

Electronic torque-turn-tension method for establishing tightening values:

The best method of making specific tightening suggestions to a customer for their critical applications is to perform a series of torque-turn-tension experiments. The most thorough procedure is to use sophisticated electronic test equipment using exact application components. The leading supplier of this type of joint tightening analyzing equipment is RS Technologies of Farmington Hills, Michigan.

According to years of research conducted by Ralph Shoberg, President of RS Technologies, the way to achieve the most consistent tension in critical joints is to tightened fasteners using the Torque-Turn Strategy of tightening instead of the Torque Strategy. To discover the optimum Torque-Turn Strategy for a given joint the torque at which the joint first comes into full alignment, or rigid, must first be determined. Secondly it must be determined at what amount of fastener turn, or degrees of rotation, from that alignment torque the desired joint tension is achieved. The Torque -Turn tightening method has been the required procedure for tightening structural bolts for many years. Through Mr. Shoberg's efforts it is now gaining wide acceptance in other industries, such as automotive, in critical application like engine head bolts and connecting rod bolts.

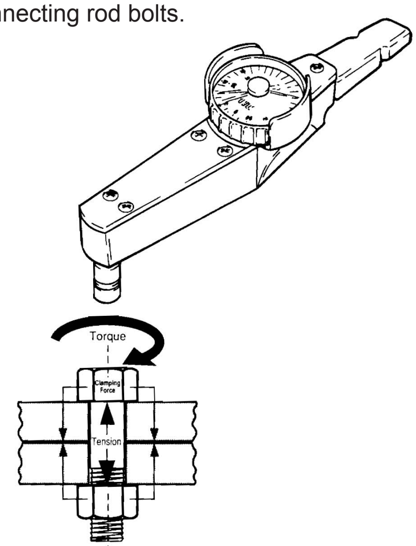

Figure 1. *Torque-turn tightening method.*

The testing procedure is as follows:

- The application is simulated in the machine with the exact components.
- A force measuring load cell is placed in the joint some place between the bolt head and nut, and torque is applied through an electronic torque transducer with angle encoder.
- Torque and tension values are recorded on a chart creating a torque-tension curve showing how much tension is created in the joint as progressively more torque is applied to the driven fastener.
- Turning angle and tension are recorded on another chart.
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- Usually the bolt or nut is driven until something in the simulated assembly fails by breaking or stripping.

- An alignment torque and turning angle are generally recommended which corresponds to a point along the torque-tension curve where both the torque and tension are still rising together. This is before the point where the torque levels off and the tension begins to fall.
- The point at which the torque levels off, and the tension in the joint begins dropping off is the point where the components are beginning to yield or fail.
- A general rule of thumb is to tighten an assembly using an alignment torque and turning angle strategy to tighten a joint to 75% of its yield strength.

Yield torque method for establishing tightening torque values:

If a supplier does not have access to the kind of sophisticated test equipment described earlier, a simpler testing method can be used to establish a recommended tightening torque. This method is not as good as that described above, but it is superior to simply referring to a torque chart or formula.

The procedure is as follows:

- Assemble 10 to 12 application joints exactly as they are to be constructed.
- With a calibrated torque wrench, drive the fasteners in the joint to yield and record the yield torque achieved in all joints. The yield torque is the value at which the indicated torque does NOT increase as the wrench continues to rotate.

  The yield point in a given application, as defined above, may be the result of the yielding of the fastener or the mating components.
- Calculate the average yield torque value for all of the tested joints.
- Multiply the average yield values by .75 to establish the tightening torque value for that given joint.

This method is simple to do by end users or suppliers. The only testing equipment needed is a calibrated mechanical torque wrench with a memory needle or an electronic wrench with a “peak-hold” feature. This method can be used for any size or type of fastener including bolts, nuts, tapping screws, and machine screws.

As stated earlier, if the sophisticated torque-turn-tension equipment is available, it should be used to gain greater insight into the dynamics of exactly what is happening in the joint at different torque levels and turning angles. If, however, this equipment is not available the simple torque wrench method is strongly recommended.

Fastener suppliers will continue to be asked for tightening recommendations as long as fasteners are sold. Suppliers can provide a valuable service to their customers by offering to do these tests, or have them done, for their customers. Due to all of the variables affecting joint tightness in each individual application, testing by one of the methods explained above is far superior to simply pulling a number from a chart.