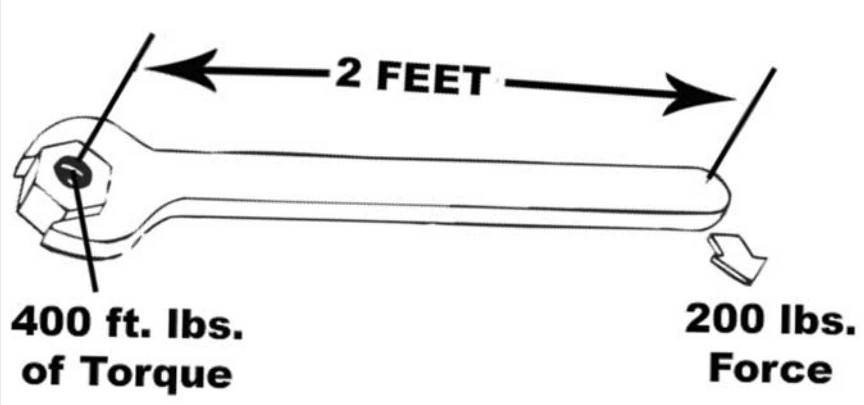
What is Torque?

According to Webster:

- A twisting or wrenching effect, or moment, exerted by a force acting at a distance on a body, equal to the force multiplied by the perpendicular distance between the line of action of the force, and the center of rotation at which it is exerted.
- A force, which tends to produce rotation. The measurement of torque is based on the fundamental law of the lever.

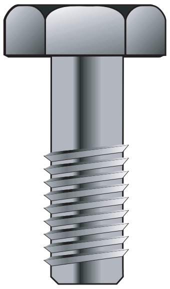
Basic Torque Formula
L (length) x F (force) = T (torque)



Example: A two foot lever at a right angle to the fastener with 200 pounds at the end will produce 400 foot/pounds of torque.

Torque Formula: L x F = T

- Torque is expressed in commonly used units of measurement such as:
- in. lbs. = inch pounds
- in. ozs. = inch ounces
- ft. lbs. = foot pounds
- Nm = Newton meter
- cNm = Centi Newton meter



What are we trying to achieve with a torque wrench?

Answer: Proper Clamping Force

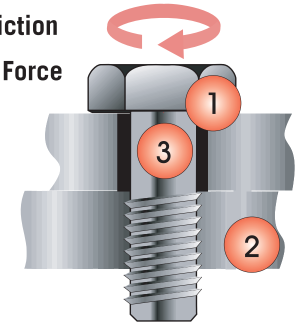
Torque and Clamping Force

Controlling the torque applied in tightening threaded fasteners is the most commonly used method for the application of clamping force. There are many factors which may affect the relationship between torque and clamping force of threaded fasteners. Some of these are: the type of lubricant used on the threads, the material from which the bolt and nut are made, the type of washers used, the class and finish of threads and various other factors. It is not possible to establish a definite relationship between torque and clamping force which will be applicable for all conditions.

Torque Versus Clamping Force

Only a small part of the torque applied to a fastener contributes to clamping force. The remaining, as much as 90% of the total applied torque, is used to overcome friction under the fastener head (or between nut and washer) and friction in thread engagement.

1. Head Friction
2. Thread Friction
3. Clamping Force

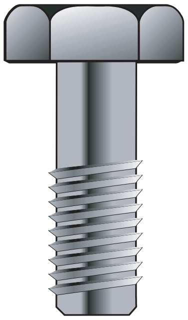


TORQUE

Head Friction:
45% - 55%

Thread Friction:
35% - 45%

Clamping Force:
10%



Torque Wrench Safety

These precautions should always be taken when using any torque wrench to avoid possible injury:

- Read instruction manual completely before using torque wrench.
- Safety glasses or goggles should be worn at all times when using any hand tool.
- Always pull, **DO NOT PUSH**, to apply torque and adjust your stance to prevent a fall.
- A "cheater bar" should **NEVER** be used on a torque wrench to apply excess leverage.
- Do not use with sockets or fasteners showing wear or cracks.
- Ratchet mechanism may slip or break if dirty, mismatched or worn parts are used.
- Make sure direction lever is fully engaged.

Torque Wrench Usage

- All mechanical torque wrenches are calibrated from 20% to 100% of full scale,therefore, they should never be used below or above those limits
- To determine which torque wrench capacity is best suited for an application, many factors must be considered. However, as a recommendation, use a torque wrench in the middle 50% of the overall capacity of the tool. This will result in longer tool life, ease of use for the operator and increased accuracy from "clicker" type torque wrenches
- Always grasp handle firmly in the center of the grip
- Approach final torque slowly and evenly
- Stop pulling wrench immediately when target torque is reached
- Never use a torque wrench to break fasteners loose
- Should be cleaned and stored properly
- Should always be stored at it's lowest torque setting
- Wrenches should be re-calibrated if dropped. Should never be used in excess of it's capacity
- Torque wrenches should be "exercised" a minimum of three times at 100% of full scale before use
- The wrench selected should be calibrated in the same torque units that are specified
- Use of a "cheater bar" will result in an inaccurate reading and can possibly damage the wrench
- Torque wrenches will last longer if reasonable care is taken. Always unwind handle to the lowest setting after each use. Do not attempt to lubricate the internal torque mechanism. Clean torque wrench by wiping, do not immerse. The wrench should be sent to a qualified calibration lab once every year or every 5000 cycles for re-calibration

Common Torque Abbreviations

Foot Pounds – ft. lbs.
Inch Pounds – in. lbs.
Inch Ounces – in. ozs.
Newton Meter – Nm
Centi-Newton Meter – cNm
Meter Kilogram – Mkg

Easy-to-use Torque Conversion Table

To Convert From	To	Multiply by
in. oz.	in. lb.	0.0625
in. lb.	in.oz.	16
in. lb.	ft.lb.	0.08333
in. lb.	cmkg	1.1519
in. lb.	mkg	0.011519
in. lb.	Nm	0.113
in. lb.	dNm	1.13
ft. lb.	in. lb.	12
ft. lb.	mkg	0.1382
ft. lb.	Nm	1.356
dNm	in. lb.	0.885
dNm	Nm	0.10
Nm	dNm	10
Nm	cmkg	10.2
Nm	mkg	0.102
Nm	in. lb.	8.85
Nm	ft. lb.	0.7376
cmkg	in. lb.	0.8681
cmkg	Nm	0.09807
mkg	in. lb.	86.81
mkg	ft. lb.	7.236
mkg	Nm	9.807

Electronic Torque Tester Information

Issues to consider when selecting an electronic torque tester:

1 **Accuracy:** Generally there are two ways of stating accuracy:

A. % of full-scale deflection or FSD
B. % of indicated value or reading

The following example will show the difference between the two methods:

Case 1 - Assume you have a 100 ft. lb. tester (maximum), and that the stated accuracy is +/- 0.5% of full scale.

At 100 ft. lb. +/- 0.5% full scale error = .5 ft, lb. This represents the "best case" error of the system. However, when a lower range is utilized, this .5 ft-lb becomes more significant. That is, on the same 100 ft. lb. tester;

at 50 ft. lb. - .5 ft. lb. error = **1% accuracy**
at 10 ft, lb. - .5 ft. lb. error = **5% accuracy**
at 1 ft. lb. - .5 ft. lb. error = **50% accuracy**

Therefore, what looks to be a good accuracy reading at full-scale actually translates into substantial error at the low range of the tester.

Case 2 - Assume you have a 100 ft. lb. tester (maximum), and that the stated accuracy is +/- 0.5% of **indicated value**.

at 100 ft. lb. - .5% error .5 ft. lb.
at 50 ft. lb. - .5 % error .25 ft. lb.
at 10 ft. lb. - .5% error .05 ft. lb.

As can be seen by the above examples, error as related to full-scale value increases significantly as you go lower in the range, while error as related to indicated value stays constant throughout the useful range of the tester.

2 **Range:** Generally when manufacturers advertise % error of full-scale, their useful ranges will be advertised from zero to full-scale. That is, +/- 0.5% accurate (full-scale) from 0-100 ft. lb. This is interesting because at zero ft. lb., the system is only accurate to within +/- 0.5 ft. lb. Basically, error goes to infinity at zero.

Furthermore, transducers which are used to convert the mechanical torque into an electrical signal may become inconsistent below 10% of full-scale deflection.

It is for the above stated reason that systems which have accuracy as related to indicated value should state the useful range to be 10% to 100% of the tester range.

Therefore, if a tester has 100 ft. lb. maximum range, it should not be used at less than 10 ft. lbs. if the desired accuracy is needed.

It is CDI's belief that in order to be completely honest to the customer, accuracy should always be stated as a percent of indicated value and the useful range should correspond to that stated accuracy. This will prevent the user from having to calculate what the real error is at any given range.

3 **Circuitry:** There are two basic ways of measuring the output of a torque transducer.

1. Analog (non-microprocessor based pure analog)

2. Digital (microprocessor based plus analog input)

Without in-depth explanations of these two systems, the following advantages of having digital circuitry are well known throughout the electronics industry.

1. Digital systems are economical, flexible and compact.

2. Digital systems improve reliability in the face of hardware imperfections.

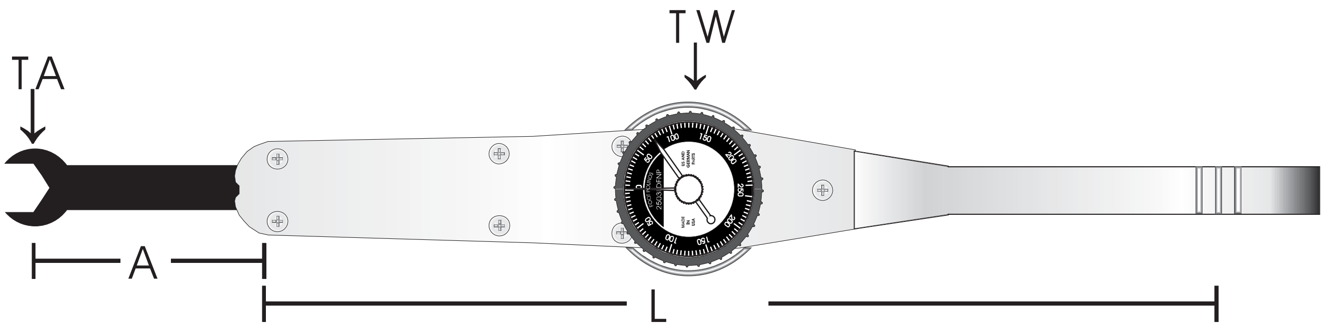
3. Digital systems allow the ability to make logical decisions, carry out digital computations (unlimited unit conversion) and store the results in memory.

Basically, full digital systems are computer controlled. It is important that the terms "digital display" or "digital memory" do not necessarily mean that the system has full digital circuitry.

Formula for Calculating Addition of an Adapter to a Torque Wrench

Formula:

$$\frac{TA \times L}{L + A} = TW$$



Length (L) = Effective length of the wrench as described below.

Dial Wrenches = The measured distance from the center of the square drive to the center ring or notch on the handle.

Micrometer Wrenches = The measured length from the center of the square drive to the center of the handle, with the wrench set at the desired torque reading.

Desired Torque (TA) = The torque value designated for the fastener with or without an adapter.

Added Length of Adapter (A) = The measured length from the center of the adapter drive to the center of the wrench square drive.

New Setting (TW) = The torque setting on the wrench allowing for the added length of the adapter. This reading will be lower than the desired torque.

Example: 250 ft. lb. Dial Wrench using a 2" long crowfoot adapter

L = Effective Length: 18.75"
Desired Torque = 250 ft. lb.
Length of Adapter = 2"

Result:

$$\frac{18.75'' \times 250 \text{ ft. lb.}}{18.75'' + 2''} = \text{Pull Wrench to 226 ft. lb.}$$