DTI's

Correct Tension for Secure Joints

A bolted joint obtains its superior characteristics through proper clamping force on the gasket contact surfaces. The clamping force, or bolt load is caused by correctly tensioned bolts. If the bolts have not reached required tension, there is insufficient clamping force and the joint is not up to specification. If excessive clamping force is used, the bolt, gasket, and/or the flange may be damaged. In either case, a leak is the probable result. Therefore, it is imperative that the proper clamping force is achieved. Direct Tension Indicators provide the means to measure bolt tension (bolt load).

Correct Tension for Secure Joints

- **Accuracy –** The bolt is tightened to a specified DTI gap which has been achieved directly by clamping force, or tension. This means you are measuring the actual outcome of your efforts instead of work input. Accuracy is not affected by bolt grip length.
- **Consistency –** Direct Tension Indicators are manufactured in small lots, and each lot is tested for consistency. A test report is kept and its lot number is marked on each DTI. In use, if the DTI's are compressed to the gap specified, each bolt is proved to be tensioned over the minimum, and under the maximum load.
- **Cost Savings –** Inspection is cost effective with Direct Tension Indicators because they are in use as long as the fastener is, do not required any special training to use or to inspect, and they help prevent rework.
- **Versatility –** The DTI can be used under the bolt head or at the nut end with a hardened washer, and it will take up to a 1:20 bevel (see figure 4).
- **Simplicity and Ease of Installation –** DTI's are easy to install with standard tools – proper clamping force is unmistakable.
- **Ease of Inspection –** The Direct Tension Indicator provides immediate visual proof that the bolt has been correctly tensioned. All you need is a feeler gauge.
- **Standardization –** Direct Tension Indicators are made to fit bolts manufactured to ASTM A193-B7 and B16, as well as equivalent metric sizes and specifications. DTI's can be manufactured and tested for use with customer specified bolt materials.

Figure 1

Direct Tension Indicators measure clamping forces (bolt load)

The Direct Tension Indicator (DTI) is a specially hardened washer with protrusions on one face (see figure 1). The DTI is placed under the bolt head or nut, and the protrusions create a gap. As the bolt is tensioned, the clamping force flattens the protrusions, reducing the gap (see figure 2).

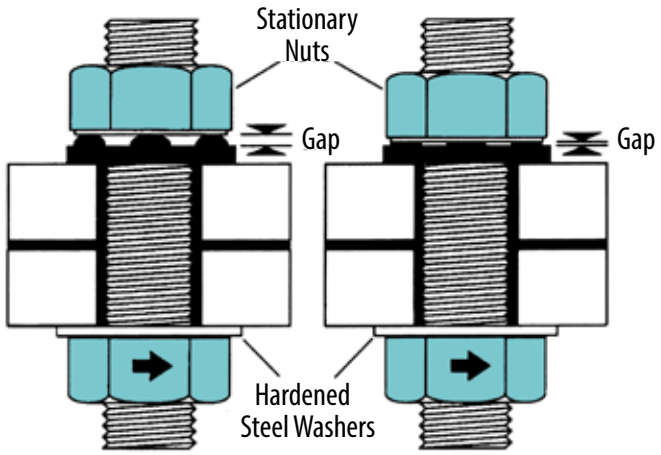

Figure 2

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DTI's

What Could be Simpler?

Correct bolt tension is evaluated by simply observing the remaining gap. A "no-go" feeler gauge is used to insure that minimum specified bolt tension is achieved. A "go" feeler gauge is used to insure that maximum specified bolt tension is not exceeded. DTI's stay on the job, providing permanent visual and measurable proof that the bolt is correctly tensioned to specification. Gap corresponds to bolt load verified by a test certificate traceable to NIST.

Tests on four 1 1/4" diameter B7 Bolts

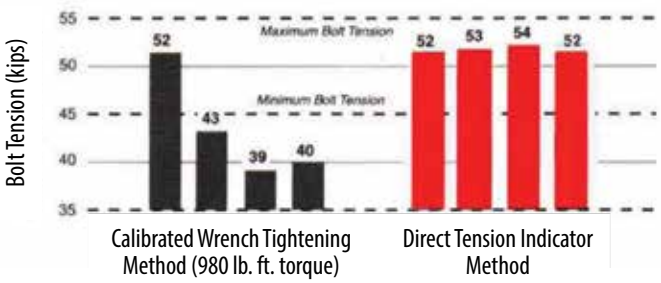


Figure 3

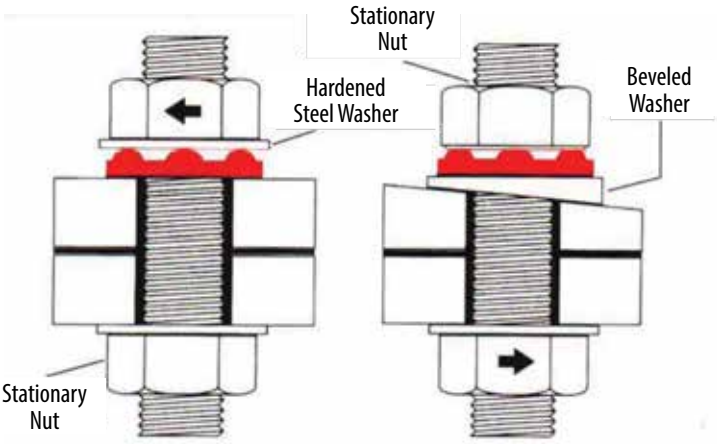
For Example:

A 1 1/4" diameter B7 bolt loaded to 50% of minimum yield will have a clamping force (tension) of 52,500 pounds. A DTI for this 1 1/4" B7 bolt will have a remaining gap of .039" at 52,500 pounds of load. A "no-go" feeler gauge .039" thick will indicate 52,500 pounds load when it is refused at one half or more of the openings between protrusions. A "go" feeler gauge .002" thinner, or .037" thick, when it is accepted at one half or more of the openings, will indicate that excessive load has not been applied. A test certificate relating gap to bolt load is provided with each lot of DTI's manufactred. Test certificates are also available relating customer specified load to gap.

Figure 3 shows the variation in bolt load (tension) on four 1 1/4" bolts which were all torqed to 980 ft. lbs. without using Direct Tension Indicators. Four more 1 1/4" bolts from the same lot were tightened using DTI's to a .039" gap. The variation in bolt load using DTI's was far less. With uniform bolt load, your fastened joint is more reliable.

DTI's provide precise measurement of clamping forces regardless of bolt condition.

Broadly defined, torque is the force, or work, required to tension a bolt. This is measured by calibrated wrenches. But the amount of work, or torque, required to properly tension bolts is significantly affected by the condition of the threads. As friction between nut and bolt threads increases, the amount of work required to install a bolt to a specific tension increases. The Direct Tension Indicators measure the resulting tension (bolt load). Input torque or procedures may change, but the bolt load indicated by the Direct Tension Indicators will be accurate.



When the DTI is installed under the nut being turned, a hardened steel washer must be used betweeen the nut and the DTI.

DTI's can be used with bevel washers to accomodate over a 1:20 bevel.

Figure 4

DTI's measure bolt load achieved – regardless of bolt condition or torque applied.

Most installation problems in the field are caused by bolt conditions. *Corrosion and dirt* – bolts that have been exposed to atmospheric conditions and weather in the field require extra work to tighten to the specified tension because of corrosion and dirt that has accumulated in the bolt threads. Therefore the mechanic may need to use a wrench of greater torque capacity.

Another way of overcoming the extra work caused by thread corrosion and dirt is by using clean, lubricated nuts and bolts. For example, lubricants such as moly or nickel paste can reduce the coefficient of friction by as much as 50 percent.

Given a wrench of sufficient capacity, and fasteners that are clean and lubricated, the time taken to properly install the bolt should be greatly reduced.

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DTI's
Questions and Answers

QUESTION	ANSWER
Will using DTI's change my torque or tension requirements?	**No.** Direct Tension Indicators measure bolt load, but do not change requirements.
If there are great temperature fluctuations in the joint: Will DTI's cause relaxation in the bolt load?	**No.** If the fasteners are tensioned according to specification, temperature creep may still occur but DTI's neither increase or decrease it.
If the stud/bolt is over-tensioned can I back the nut off and use the same DTI again?	**No.** Once the protrusions on the DTI's are compressed past the designated amount, a new DTI must be used.
If enough clamping force has not been achieved when the gap is measured, do we need to start from the beginning again?	**No.** If the "no-go" gauge still fits in the gap, simply create more tension (and therefore more clamping force) until the "no-go" gauge does not fit but the "go" gauge still does fit.
Is it possible for my company to get a demonstration of the Direct Tension Indicators?	**Yes.** We are happy to provide additional information and demonstrations. We even have a video on DTI's.
Has there been any testing to confirm the information on DTI's?	**Yes.** Please refer to the technical reports section of this brochure. Then call (800) 231-1075 or (281) 449-6466 for any reports you would like to receive.

FACTS:

Torquing a stud or bolt creates tension
Tension in the stud/bolt creates clamping force on the joint
Clamping force (also referred to as bolt load) on the joint, in the correct amounts, holds the gasket properly and creates a secure critical joint.

Stress relaxation and fatigue

Stress relaxation tests conducted over long periods on cold worked steel show that no measurable cold creep is experienced at temperatures below 302°F (150°C). This is confirmed by tests on Direct Tension Indicators which, after bolting up to indicated load at ambient temperature, show no relaxation in bolt tension after 2,700,000 cycles. The load tests conducted were from 0 to 0.6 times proof load on bolts tightened to proof load with DTI's.

Technical reports

The Direct Tension Indicator has been thoroughly tested. A comprehensive study entitled "Bolt Tension Control with a Direct Tension Indicator", was conducted in August 1972 by J.H.A. Stuick, A.O. Oyeledun, and J.W. Fisher of the Fritz Engineering Laboratory, Lehigh University, Bethlehem Pennsylvania. The description and results of this and other tests are available in the following series of technical reports and may be obtained on request.

- #23 Corrosion-Exposed Structures
- #24 Unloading and Reloading
- #25 Stress Relaxation
- #26 Fatigue
- #29 A490 Tightening
- #30 Time Trials of Tightening Methods

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