Stamping The Future

TENSION INDICATING WASHERS FOR BOLTS, ANCHORS AND STUDS

TurnaSure DTI
DIRECT TENSION INDICATOR

TurnaSure ViewTite®
NUT SIDE SELF-INDICATOR

The proven path to accurate tensioning, used on major structures worldwide for 55+ years - manufactured to EN14399-9, DASt Guideline 021 and ASTM standards F959/F959M and F2437/F2437M for Inch and Metric series Structural Bolts, B7 Studs, Grade 55 and 105 Anchor Bolts, SAE Grade 5 and Grade 8 Cap Screws, and a host of other applications requiring high accurate clamp force

www.WroughtWasher.com

“KDOT does not have the time, experience or personnel available to use bolting methods which do not include DTI’s. The versatility afforded our staff, at any time after the operation is completed, to inspect with confidence the proper installation of bridge fasteners is a requirement written into our Specification. The use of DTI’s coupled with KDOT’s calibrated turn-of-the-nut, our field operations report a substantial increase in bolting operation efficiencies, and confidence.”

John Patrick Jones, MS PE
Former Kansas State Bridge Design Engineer

The TurnaSure DTI

Setting the Standard for Correctly Tensioned Bolted Connections!

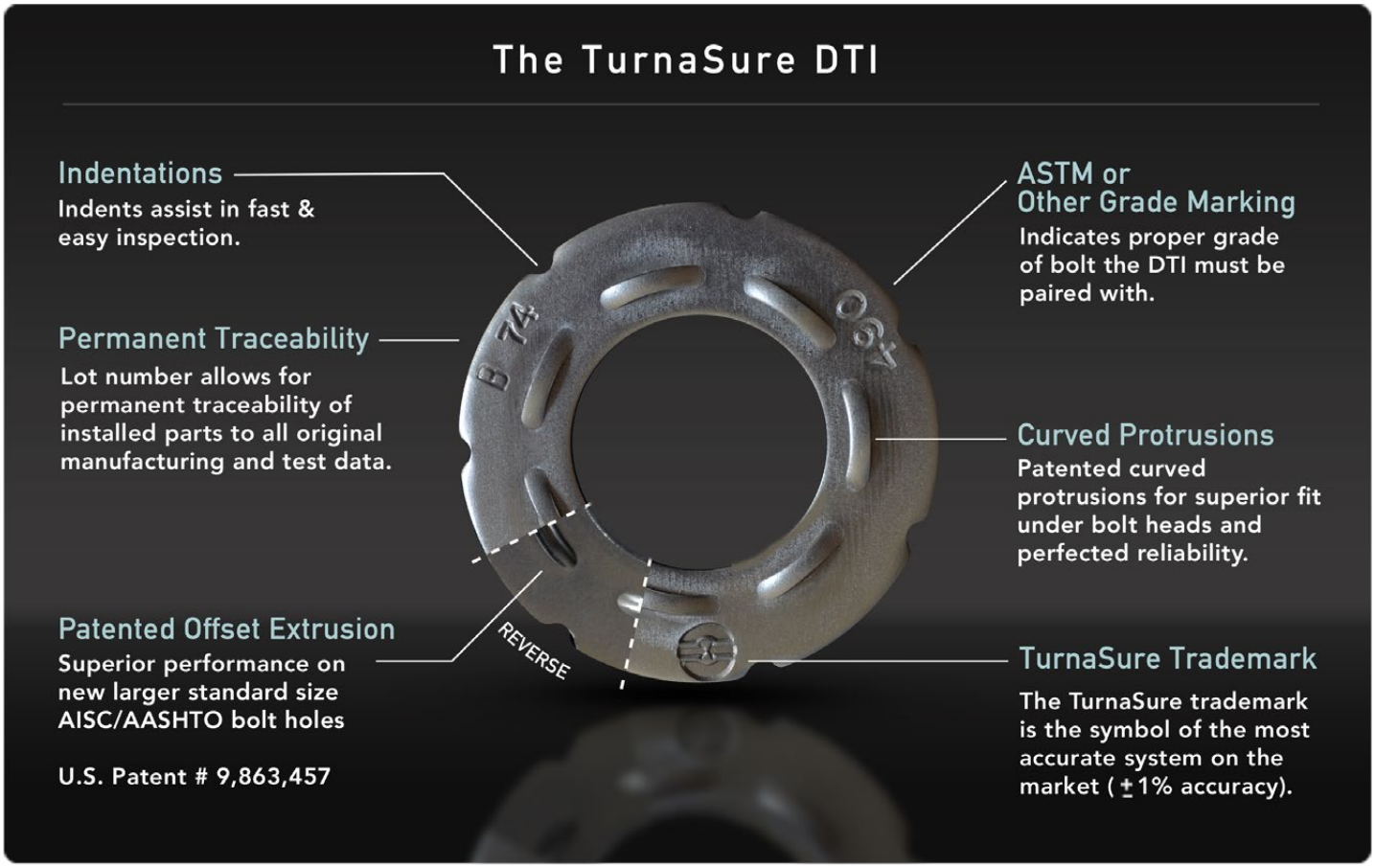
The TurnaSure DTI is the world's simplest cost effective solution to control the tensioning of bolts. These unique, patented fasteners deliver consistent, reliable bolt tension, along with installation and inspection efficiency. They are used every day to achieve required tension loads on bolts in countless applications including: structural steel buildings and bridges, studs used in the petro-chemical industry, anchor bolts, and with SAE cap screws in Off-Highway automotive applications.

Used Wherever Tension Matters

For half a century, TurnaSure DTIs have been used throughout the world on major buildings, bridges and other important steel structures. They are also ideal for use on pressure vessels, valves, pipe flanges, anchor bolts, wind turbine blades, cantilevered road signs and traffic signals, truck chassis maintenance and countless other applications.

Tested and Proven

The accuracy and reliability of TurnaSure DTIs have been proven time and time again in laboratory tests and industry studies. In test after test, the TurnaSure DTI has prevailed against other methods of bolt tensioning. And just as importantly, bolts tensioned with TurnaSure DTIs retain their tension for the long haul. TurnaSure DTIs retain their accuracy regardless of their surface condition during tightening, whether oiled, coated or even rusted!

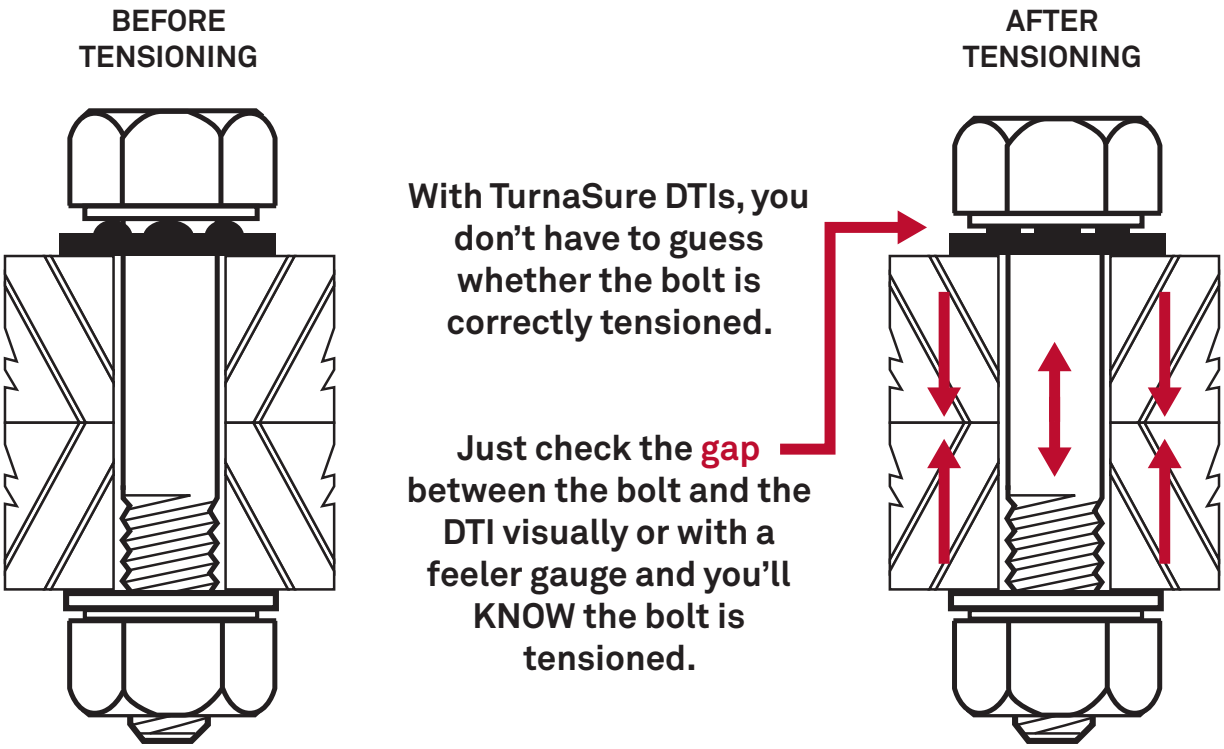


How a TurnaSure DTI Works

Direct Tension Indicators work when the patented protrusions are compressed as the axial tension force in a bolt or stud is increased by rotating a nut.

The spacing of the protrusions allows the bolt to attain correct tensioning which can be verified through inspection of the gap between the bolt head and the surface of the DTI. This gap provides an easy and reliable method of checking the bolt tension, by inserting a feeler gauge between the protrusions (our edge indentations make it easy to find the right place to insert the gauge). When the feeler gauge indicates you have compressed the gap sufficiently, you know the bolt is correctly tensioned. It's quick, easy and reliable, and it's the best wya to ensure correct tensioning

MIND THE GAP!



How a TurnaSure DTI Works

But What About Torque?

Except for sufficient lubrication to allow the nut of the assembly to be rotated under load, “torque” has no effect on the process. (Note: It is bolt tension, not torque that determines the preload in a joint).

Flexibility in Assembly!

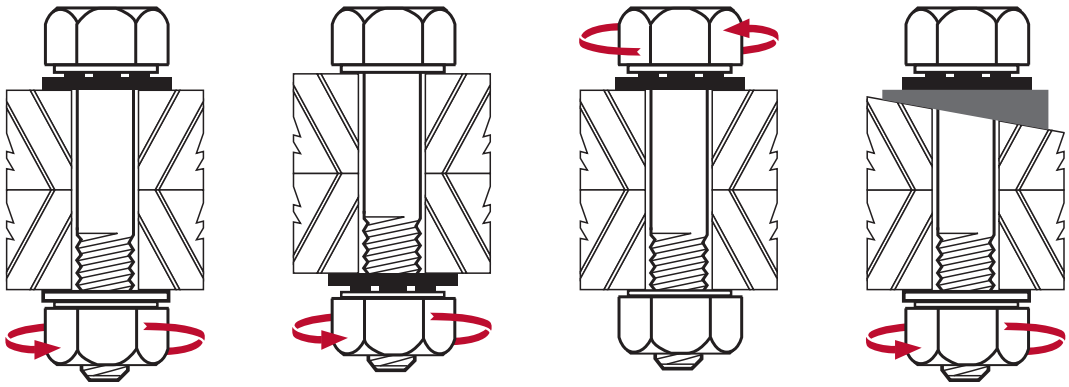
While the most common method of use is to place the DTI under the bolt head and turn the nut, DTIs can be used in several alternate assembly methods, giving you the flexibility you need:

Method 1
DTI under head – Turn nut to tension, bolt head held.

Method 2
DTI under the nut – Turn the nut to tension. *(Also applies to ViewTite™)*

Method 3
DTI under the bolt head – Turn the bolt head to tension. *(Also applies to ViewTite™)*

Bevel Washers
DTIs can also be used with bevel washers to accommodate over a 1:20 bevel.



Leave the Hardened Washers Behind

The unique curved protrusions on TurnaSure’s standard DTIs have been shown in studies to work more effectively if the hardened washer is eliminated when tensioning Standard DTIs under the nut. NOTE: ViewTite® DTIs always utilize a hardened washer to ensure maximum accuracy.

Respected Worldwide

TurnaSure DTIs and ViewTite® Self-Indicators are covered by patents and trademarks granted and pending worldwide, including the USA, European Union, India, China and Japan.

To specify TurnaSure® DTIs for use on structural steel projects, use the following:

“All High Strength bolts shall be tightened and inspected with ASTM F959 Direct Tension Indicators to aid in indication of correct bolt tensioning such as with TurnaSure DTIs or approved alternative.”

The ViewTite® Nut-Side Self-Indicator

Meet the newest addition to the the world's most popular line of Direct Tension Indicators

TurnaSure ViewTite®

NUT SIDE SELF-INDICATOR

Manufactured to ASTM F959

GREEN MEANS GO!

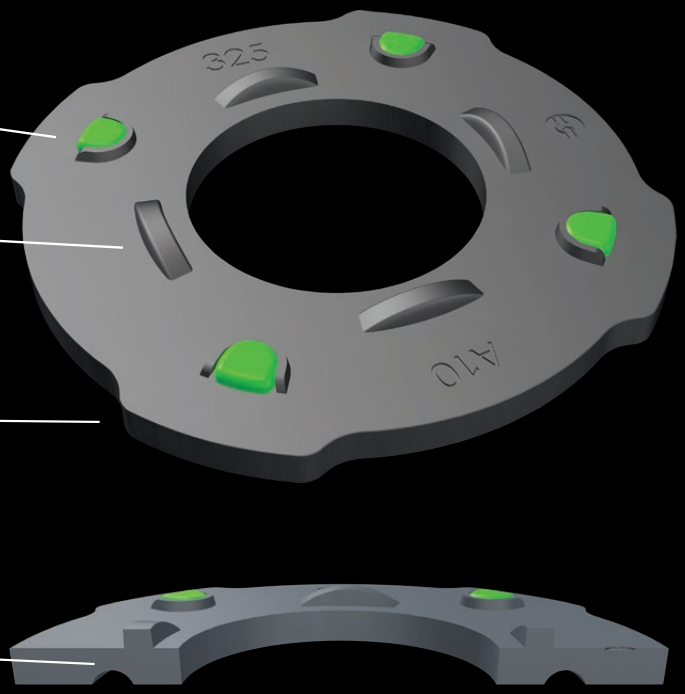
The most reliable tensioning. Now with fast, easy visual indication!

Reduced height 'horseshoe' pockets encapsulate a precise measure of elastomer that appears only when the bolt has reached minimum required tension.

Patented curved protrusions (#7,635,243) are the most reliable and accurate ever made. Protrusions ('bumps') compress smoothly and evenly as bolt tension increases.

Exterior lobes provide a platform to ensure that the elastomer is readily visible when tensioning is completed.

Patented 'offset extrusion' design (#9,863,457) ensures performance and compatibility with the new larger AISC 'standard holes' in larger diameters. **No need for extra washer underneath!**



U.S. Patent No. 10,738,817 B2

Poorly lit construction site? Nighttime Inspection? No problem!

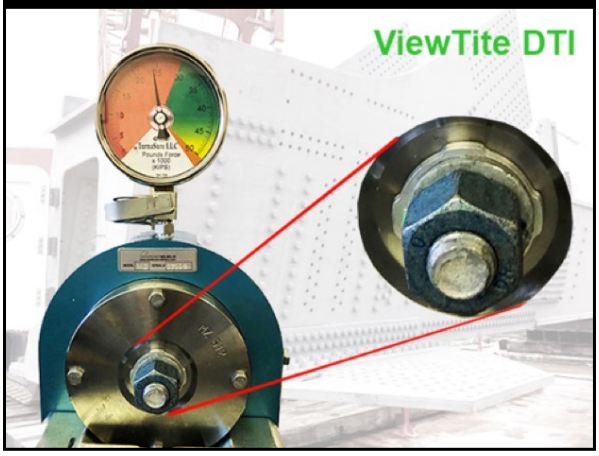
The elastomer in ViewTite® Nut-Side Self-Indicators glows brightly under UV 'black' lights, making inspection a snap.

ViewTite® DTIs in use on the Verrazzano-Narrows Bridge

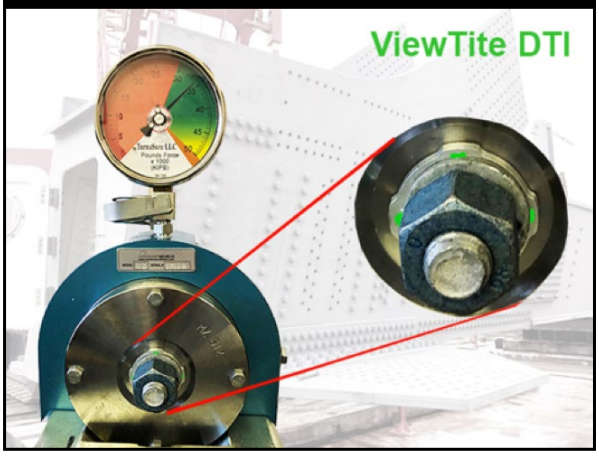
The ViewTite® Nut-Side Self-Indicator

TurnaSure manufactures the most popular and most accepted product range of Direct Tension Indicators for assuring correct and accurate clamping forces in bolts, anchors, and studs. TurnaSure's product line now includes the new ViewTite®, the nut-side self-indicating washer that makes inspection as easy as 1, 2, Green!

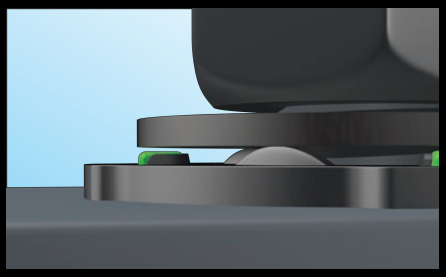
Snug Tightened



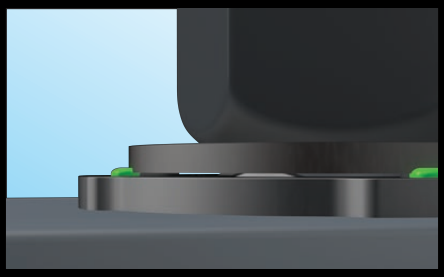
Fully Tightened

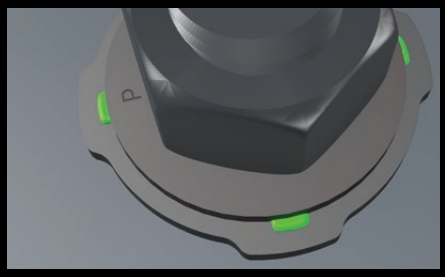


BEFORE TIGHTENING



AFTER TIGHTENING





WHEN YOU SEE GREEN... you know your structural bolts are correctly tensioned!

To specify ViewTite® self-indicating DTIs for use on structural steel projects, use the following:

"All High Strength bolts shall be tightened and inspected with ASTM F959 Direct Tension Indicators that also emit a colored elastomer to visibly indicate correct bolt tensioning, such as ViewTite DTIs from Wrought Washer."

DTI Applications

TurnaSure DTIs and ViewTite® Self-Indicators are the ideal solution whenever achieving and maintaining bolt tension is critical. They are in use in some of the biggest buildings, bridges and structures in the world, but they are also the perfect solution for a wide range of other applications.

Petro-Chemical

Today's bolted joints must be designed with tomorrow's ever stricter safety and environmental challenges in mind. TurnaSure DTIs provide correct tensions for secure leak-free bolted and gasketed joints.

TurnaSure DTIs were introduced to the petro-chemical industry at the Offshore Technology Conference in Houston Texas in 1994, where they received an Award of Merit, and have been seen continuous use in the industry ever since.

DTIs for studs are now covered by ASTM F2437. They are available for B7 and B16 studs. TurnaSure's unique patented geometry produces protrusions with enhanced load resistance, making it possible to keep hardness below 22HRC, per the ASTM maximum hardness requirement for these studs.

Wind Turbines.

Wind turbines are engineered to generate clean power day in and day out for decades. It is bolts that hold it all together and make that possible. It is essential that these bolts are correctly tensioned the first time around, and it important to be able to easily inspect them for this, so they stay that way.

TurnaSure offers a complete range of DTIs for wind turbines, from blade bolts, to anchor bolts for the foundation (covered under ASTM F2437/ F2437M) and tower bolts and nacelle and gearbox bolts. Every bolt in the system must be correctly installed and tensioned to ensure the integrity of the entire system. TurnaSure DTIs make certain that every bolt is correctly tensioned to the engineered clamp loads.

DTIs have also been specially developed to bolt on composite turbine blades where exact tensions are absolutely critical for this special material.

For more on the use of DTIs for Petro-chemical applications, contact us at
800-525-7193 (US & Canada) or **215-750-1300** (International)

DTI Applications

Automotive

Use of DTIs manufactured to Grade 5 and Grade 8 strength grades per ASTM F2437/F2437M for off-highway vehicle and automotive applications is steadily growing. DTIs are excellent for assuring high accurate clamping forces that insure against vibration loosening or fatigue failure of fasteners due to insufficient tension.

Highway and Traffic

Tension matters on the highway. There have been cases of catastrophic failures of signal, light and sign structures due to inadequate tightening practices in these installations. This is because natural and traffic-induced wind generates forces that exert tensile loads on anchors that are insufficiently tensioned. When anchor bolts are not correctly tensioned and are subjected to stress reversal, this in time can result in failure of the anchor bolts by fatigue.

Tension verification with DTIs ensures that the installed bolt preloads are greater than the tension force that the fasteners will experience in service, even in hurricane force wind conditions.

Grade 55 DTIs and Grade 105 DTIs to ASTM F2437/F2437M are gaining in popularity for anchorage of large traffic signal, light and signage installations. Several DOTs require the use of DTIs in these applications to eliminate the risk of loose bolts.

Other Anchors and Proprietary Applications

At times designers wish to establish both a minimum and maximum tension for a special application. DTIs can be provided along with Load-Gap charts which enable one to choose applicable ‘go’ and ‘no-go’ feeler gauges to ensure that bolt tension is higher than a required minimum, yet lower than a desirable maximum. DTIs were first developed and used in this manner for seismic bolted connections for which slip-resistance needed to predictably land between upper and lower bounds.

For more on the use of DTIs for Wind or Automotive applications, contact us at
800-525-7193 (US & Canada) or **215-750-1300** (International)

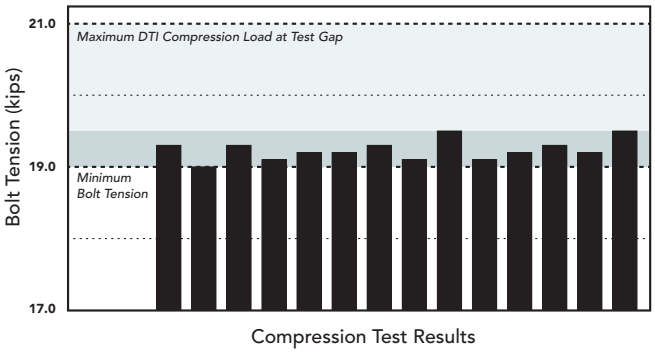
The Benefits of Using DTIs

Accuracy

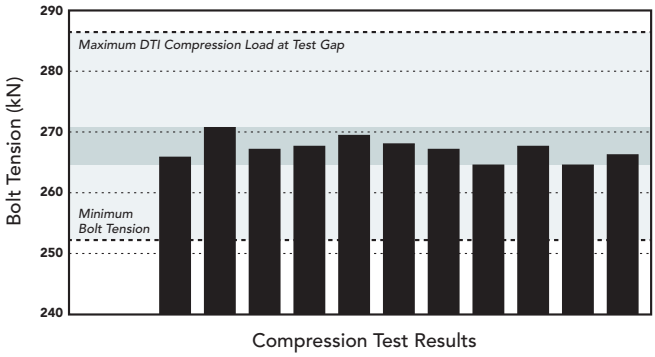
TurnaSure DTIs allow accurate bolt tensioning across a wide range of conditions.

TurnaSure's goal has always been to enable the most accurate bolt tensioning, no matter the condition or size. Advances in raw materials (such as hardening via precise cold rolling, followed by annealment prior to manufacturing) have allowed us to continue to raise the bar on DTI accuracy. Laboratory tests have shown that TurnaSure DTIs consistently achieve the minimum required bolt tension.

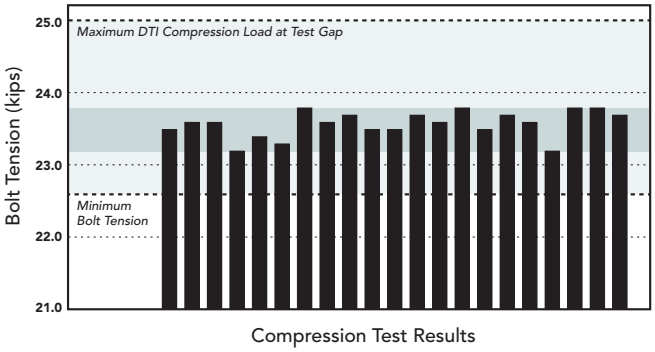
ASTM F2437 1" Grade 55 (for Anchor Bolts)
DTI Lot 0155A1 MG



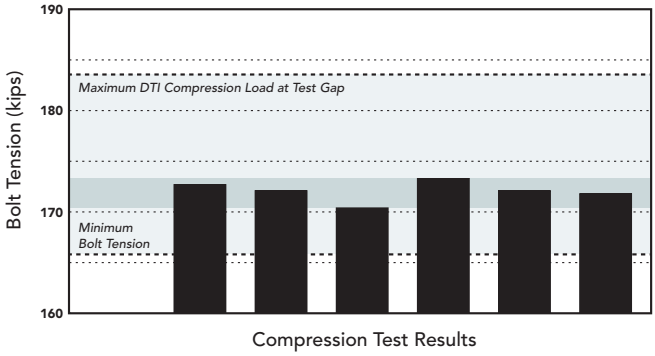
M30 SAE 8.8 (for Cap Screws)
DTI Lot 30C8A2



ASTM F2437 3/4" SAE Grade 5 (for Cap Screws)
DTI Lot 34G5A1



ASTM F2437 2" Grade 105 (for Anchor Bolts or B7/16 Studs)
DTI Lot 02BA4MG



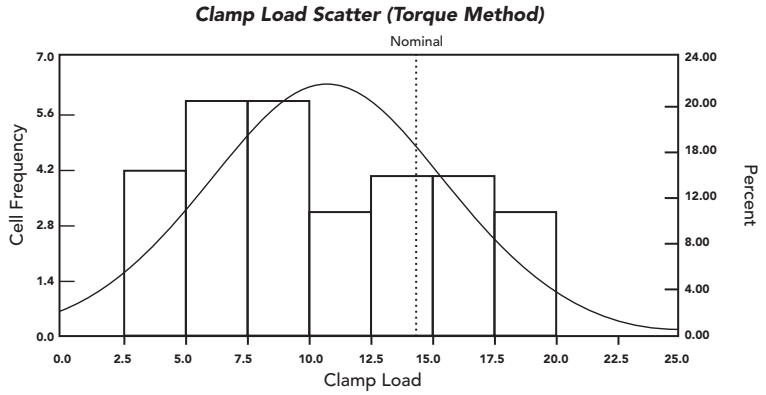
TurnaSure utilizes and independent 3rd party A2LA-accredited laboratory to confirm internal test results. Compression load results are directly traceable to the National Institute of Standards and Technology (NIST). Such testing indicates that the accuracy of TurnaSure DTIs is remarkable, with a typical standard deviation equivalent to ±1% of measured load. Every TurnaSure production lot is identified by a lot number marked permanently on each DTI, assuring full traceability to all production records and raw material sources. All TurnaSure DTIs are manufactured in the USA from steel melted and manufactured in the USA.

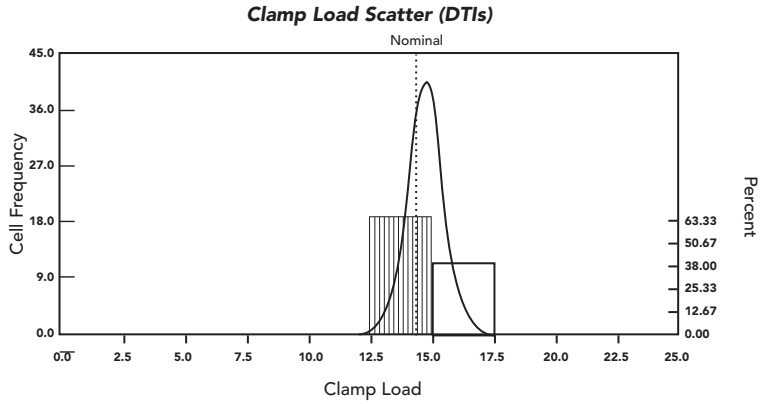
For more on the Accuracy of TurnaSure DTIs, visit **www.TurnaSure.com/research** and view reports **02**, **13** and **15**

Compared to the Torque Method

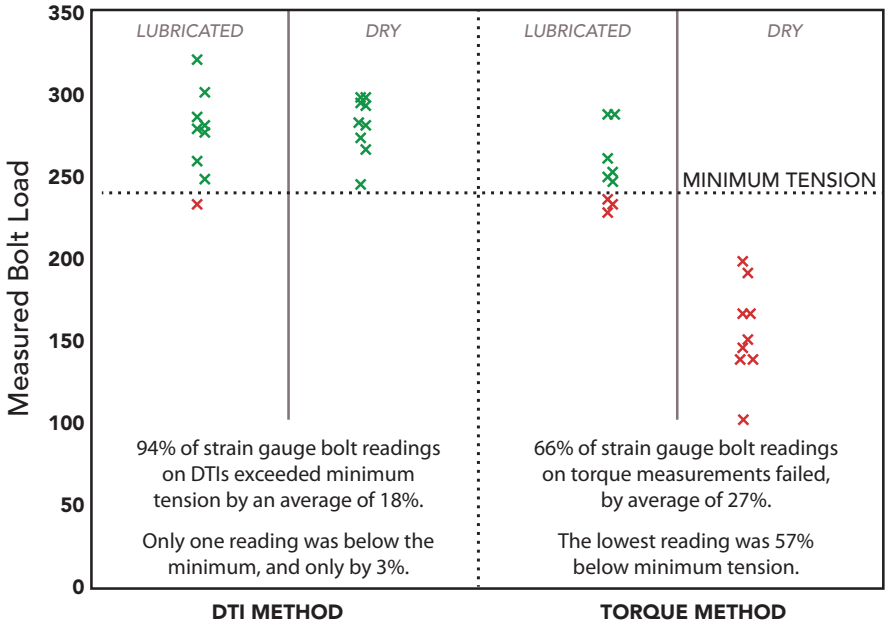
The most common tightening method is torque control. Torque is not measuring tension in a bolt or anchor. It merely measures the force required to turn a nut as a threaded fastener is tightened.

As the two graphs to the right indicate, the actual clamp load generated while using the torque method shows a tremendous amount of variation, while that generated by using TurnaSure DTIs is remarkably consistent. The DTI method is far more accurate than the torque method.





DTIs in actual structural connections compared to torque.
Final tensions monitored with 9 strain gauged bolts per connection.



A test conducted in the Applus Laboratories in Barcelona, Spain, in a tightly controlled research setting using strain-gauged bolts, compared the bolt load observed in bolts tightened using DTIs vs those tightened using the torque method in both lubricated and dry conditions. The results (illustrated here) show the superior accuracy of the DTI method, contrasted with a stunning 2/3 of the torque method bolts having failed to achieve the required load!

For the full report, visit **www.TurnaSure.com/research** and view report **15**

The Benefits of Using DTIs

Long-term Reliability and Minimization of the Effects of Prying Action

Long term relaxation in a DTI bolted joint was first studied in 1963. **24 hours after initial tightening baseline clamp load was measured and recorded, and for the following eight years routine clamp load measurements showed that there was no detectable relaxation in the joint.**

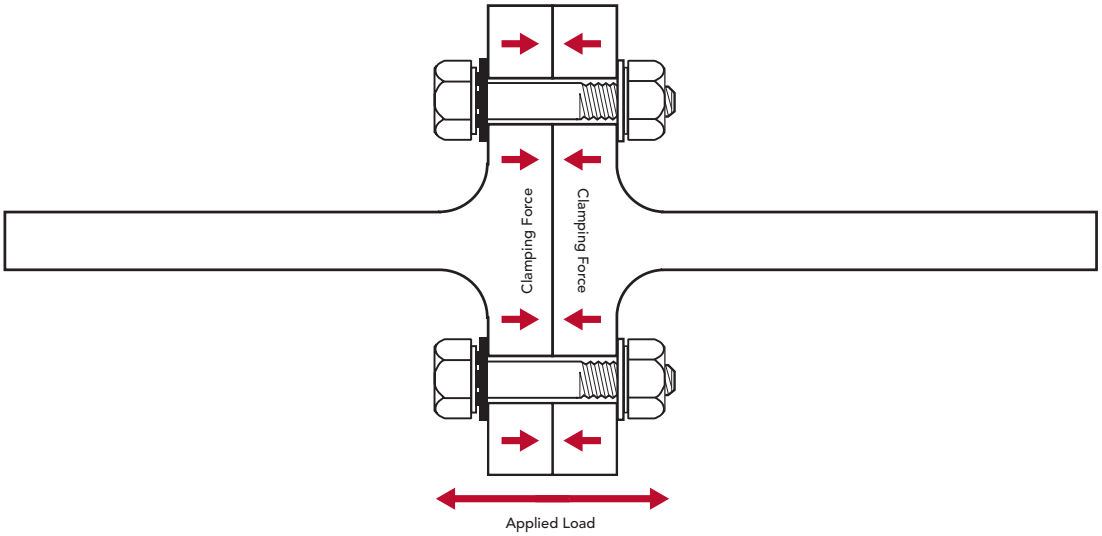
A more recent in depth study on long term bolt relaxation with or without DTIs was conducted in 2012 by Load Control Technologies of Pennsylvania USA, using ultrasonic measurement techniques; the study was overseen by Rowan University. This study shows not only were all bolts properly tensioned when using DTIs, but bolts not tightened using DTIs were often not properly tensioned. This study found that the higher the initial bolt tension, the higher the relative relaxation, typically ~8% whether DTIs were in the assembly or not.

Research at the University of Leeds in England in 1982 showed that DTIs minimize load losses in joints subject to momentary overloading. Bolt load recovery was enhanced by ~20%, as DTI bumps are more elastic than bolts. The University of California confirmed this beneficial effect using DTIs on seismic isolators. Properly tensioned bolts experience little change in stress under prying loads. The presence of DTIs has been shown by research to reduce loss of bolt pretension when connections are subject to prying action. Minimizing prying action and maximizing bolt preload improves the fatigue life of fasteners.

For more on the Reliability of TurnaSure DTIs, visit **www.TurnaSure.com/research**

Fatigue Loading and Cyclical Stresses

The first study of fatiguing in joint incorporating DTIs was conducted in Cambridge, England in the 1960s. Bolt condition was studied after nearly three million stress cycles of loading and unloading, where the applied forces equaled 60% of the induced bolt tension determined by DTI gap closures. **There was no change in bolt load or any loosening after the multiple stress cycles had been applied.**



A study conducted at SPS Contract Research in Jenkintown, Pennsylvania on a Junkers test bed which exerted transverse vibration through joints with and without DTIs discovered the previously unknown fact that DTIs provide significant resistance to vibration loosening. **For comparative results, SPS were able to set the amplitude of the vibration high enough to loosen all joints which used nylon insert lock nuts, yet none of the joints in which DTIs were installed.**

The Benefits of Using DTIs

It is very important to make sure that the applied load to connections subject to cyclic stresses along the bolt axis is always significantly lower than the clamping force. If applied loads are greater than the clamping force, bolts will loosen or fail by fatigue. TurnaSure DTIs assure the required clamping force is present in the connection.

For more on Fatigue Loading of DTIs, visit **www.TurnaSure.com/research**

Corrosive Environments

Research has shown that TurnaSure DTIs are well suited for corrosive environments. Several corrosion studies have been completed on bolt joints using DTIs. One study was undertaken in 1985 at the Mellon Institute in Pittsburgh PA. This research demonstrated that when DTIs are installed to a gap of 0.005in or less, long-term penetration of moisture through the gaps was insignificant. In 2002, another study was conducted by KTA Tator also of Pittsburgh PA on uncoated Type-3 "weathering steel" DTIs. This study concluded that **the curved DTI protrusions actually prevented corrosion inside the bolt heads or nuts**. The residual DTI gaps were quickly sealed closed by the natural patina buildup associated with Type 3 steel. A 3rd study on TurnaSure DTIs themselves proved their accuracy is unaffected by rust or oil surface finish.

For more on DTIs in Corrosive Environments, visit **www.TurnaSure.com/research**

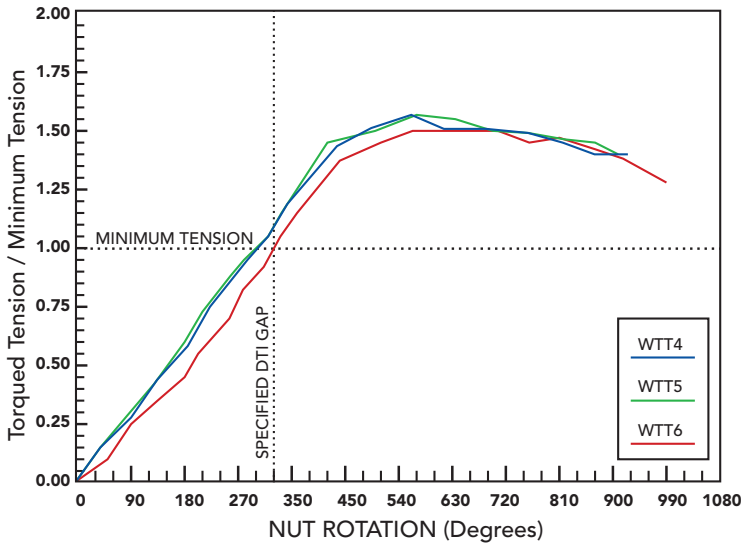
Reduced Likelihood of Yielding

DTIs offer additional benefits beyond just assurance of tension. Using DTIs in your bolted connections dramatically reduces the likelihood of bolt yielding. The additional compression potential of the DTI protrusions once the bolt has achieved the desired load is able to absorb supplemental nut rotation without passing that stress on to the bolt.

The extra "compliance" when a DTIs is in grip is shown dramatically in this graph. On 7/8" x 5" A325 bolt, DTI contributes to a massive 550° of extra nut rotation before bolt ruptures. Note load never falls below minimum.

Source University of Idaho Research Report published in 1999 by AISC

Normalized Torqued Tension vs. Nut Rotation: 7/8-in. A325 Weathering Steel Bolts & Epoxy-Coated DTIs, 5.0" Bolt Length



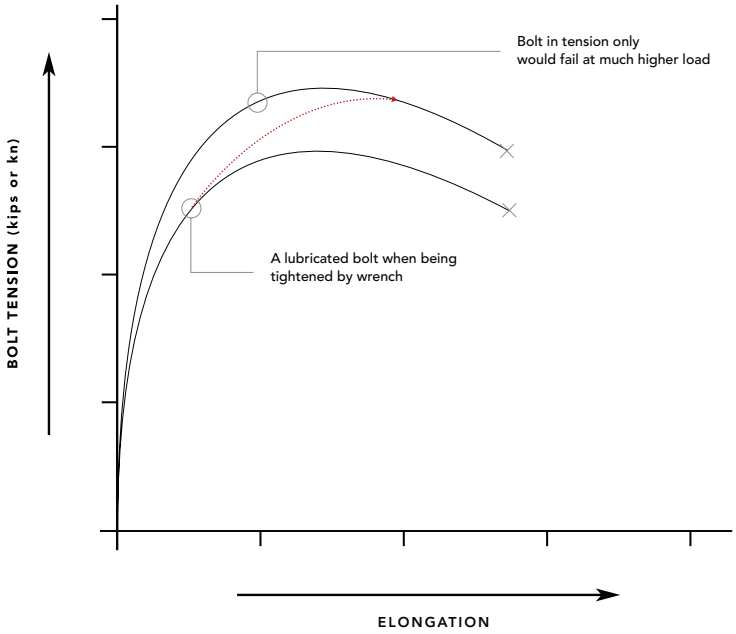
For more on Yielding in bolts using TurnaSure DTIs, visit **www.TurnaSure.com/research**

The Benefits of Using DTIs

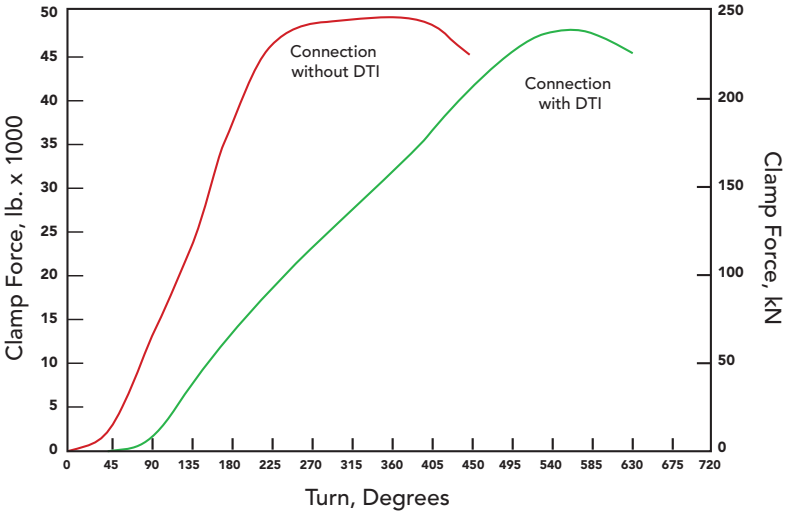
GRAPH SHOWING RESERVE TENSILE STRENGTH OF BOLTS AFTER TIGHTENING

This diagram demonstrates a bolt yielding while it is being "twisted" (i.e. nut being torqued) at much lower loads vs. the same bolt yielding in direct tension at much higher loads. The conclusion is bolts are much stronger after tensioning than while being tightened.

Bolts can rupture at very low tensions if the threads are dry or damaged as the nuts freeze or lock up. TurnaSure have experienced no delayed fracture of a bolt with fully flattened DTIs in fifty Years!



Turn-Tension Comparison
3/4" SAE Grade 8 with and without DTIs



This graph demonstrates that with a DTI in the grip, the joint acts more elastically as more rotation of the turned element is needed to attain identical peak tensions. Thus, DTIs installed using angle-controlled installation tools allow for even more precision in reaching a specified minimum or target clamp force.

Cost Savings

DTIs can enhance your profitability. The quick, easy, reliable inspection (using the feeler gauge method) saves time and money. The ViewTite® self-indicating washer eliminates the guesswork bolting crews would otherwise contend with in order to identify where they left off with bolt tightening on the previous day.

While efficiency in installation and inspection offer real savings, the biggest cost saving from the use of TurnaSure DTIs is assurance against fastener loosening or fracture in service. Costly maintenance and even complete catastrophic failures have resulted from poorly installed bolts and nuts.

The highly accurate clamping forces afforded by DTIs significantly reduces these incidents and improves the durability of your assemblies.

For more on Cost Savings of TurnaSure DTIs, visit **www.TurnaSure.com/research** and view reports **09**, **11** and **20**

Types, Grades and Sizes

The Perfect Fit for the Perfect Tension

TurnaSure manufactures the world's largest variety of Direct Tension Indicators (DTIs). Our extensive catalog of sizes and grades offers up the perfect size for virtually any bolting need. DTIs can be furnished in any coating that is also applied to the bolts and nuts themselves.

ASTM F2437 for 55 KSI anchor bolts (DTI sizes are as per ASTM Standard)

½	⅝	¾	⅞	1	1 ⅛	1 ¼	1 ⅜	1 ½	1 ⅝	1 ¾	2	2 ¼	2 ½	2 ¾

ASTM F2437 for 105 KSI Anchor bolts (DTI sizes are as per ASTM Standard)

½	⅝	¾	⅞	1	1 ⅛	1 ¼	1 ⅜	1 ½	1 ⅝	1 ¾	2	2 ¼	2 ½	2 ¾

ASTM F2437 for Grade 5 and Grade 8 SAE Cap Screws (DTI sizes are as per ASTM Standard)

¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1	1 ⅛	1 ¼	1 ⅜	1 ½	1 ⅝	1 ¾	2	2 ¼	2 ½

DTIs for SAE Grade 8.8 and 10.9 Metric Cap Screws (DTI sizes are as per Bolt Standards)

M 8	M10	M 12	M14	M16	M18	M20	M 22	M24	M 27	M30	M33	M36

DTIs for DIN 6914 (DTI sizes are for 10.9 as per Bolt Standards)

M 12	M16	M20	M 22	M24	M 27	M30	M33	M36	M42	M48	M56	M64	M72

EN 14399-9 EU Standard for H8 and H10 Structural Bolts (Sizes over M36 are ASTM F2437M as per DASt Guideline 021)

M 12	M16	M20	M 22	M24	M27	M30	M36

ASTM F959M USA Standard for type 8.8 (325) and 10.9 (490) Structural Bolts (DTI sizes are as per ASTM Standard)

M 12	M16	M20	M 22	M24	M27	M30	M36

ASTM F959 USA Standard for type 325 and 490 Structural Bolts (DTI sizes are as per ASTM Standard)

½	⅝	¾	⅞	1	1 ⅛	1 ¼	1 ⅜	1 ½

ViewTite® Self Indicating DTIs to ASTM F959 for structural bolts are available from 5/8" to 1 ½" in type 325 and ¾" to 1 ½" in type 490. In metric they will soon be available for most ASTM F959M Structural Bolts as well as most EN 14399 sizes. Please inquire about availability of any additional sizes.

TurnaSure also supplies special DTIs to customer's individual specifications of size and clamp load specifications in a variety of materials including stainless steel. These include our latest capability of manufacturing super high load Direct Tension Indicators with compression loads of 600,000lbs (2,600+ kN) tension in nominal sizes up to 3in or M76.

Stamping The Future

International Headquarters
2100 South Bay Street
Milwaukee, WI 53207
USA

Toll-Free from US & Canada
800-525-7193

International
Tel: 215-750-1300
Fax: 215-750-6300

www.WroughtWasher.com