

Procedure for Testing Direct Tension Indicators (DTI) Assemblies

1. Scope:

This test is to ensure that the bolt will be at or above the specified minimum bolt tension after installation when the direct tension indicator has been compressed to the specified maximum gap and that the bolt will not have excessive plastic deformation when the direct tension indicator is compressed to the specified minimum gap.

2. Apparatus:

- 2.1 Calibrated bolt tension measuring device: (Skidmore-Wilhelm or other approved device).
- 2.2 0.005 inch tapered thickness gage: This is the same thickness gage that is to be used to inspect the bolts after installation and is to be supplied by the Contractor per the standard specifications.
- 2.3 Direct tension indicator assembly: (Bolts, nuts, washers, and direct tension indicators)
- A. Three direct tension indicator assemblies for each diameter, length, rotational capacity lot and direct tension indicator lot are required. Three additional direct tension indicator assemblies with three long bolts are required for testing short bolts as defined below:

NOTE: A long bolt is defined as a bolt with adequate length to be properly installed in a calibrated tension measuring device. A short bolt is defined as a bolt that is too short to be tested in the device.

Short Bolts for DTI Testing

Lengths shorter than listed below require additional longer bolts for DTI testing.

Size	1/2"	5/8"	3/4"	7/8"	1"	1 1/8"	1 1/4"
Length	2"	2 1/4"	2.5"	2.75"	3"	3.25"	3.5"

- B. The direct tension indicators, bolts, nuts and washers shall conform to the project specifications and shall be new and unused. They shall be randomly selected from the material to be used in the work unless long bolts are required.
- 2.4 Wrenches: Tensioning of the bolts shall be accomplished with a hand wrench such that tension readings can be recorded exactly. The use of a torque multiplier or a handle extension may be necessary and is acceptable. The use of an impact wrench for this testing is not allowed. A second wrench is required to prevent rotation of the bolt head while the nut is tightened.

3. Procedure:

3.1 Long bolts.

- A. Direct tension indicators (See figure 1) are made in different sizes, types and have different numbers of spaces. They are also available in plain or coated (Galvanized or epoxy coated) finishes. Verify that the direct tension indicator is of the size, type and finish specified and that the number of spaces is in accordance with table 1. Record this information on the DOT-96.

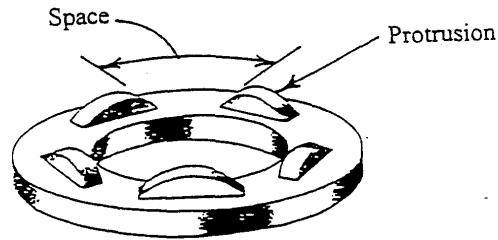


Figure 1
(Direct Tension Indicator)

Table 1

DTI dia. (in.)	Number of spaces								
	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Type 325	4	4	5	5	6	6	7	7	8
Type 490	N/A	N/A	6	6	7	7	8	8	N/A

- B. Direct tension indicator assemblies: The bolt, nut, washer and direct tension indicator shall be assembled into the calibrated bolt tension measuring device in the same configuration as is to be used in the work (See figure 2). Face plates, inserts and spacers with standard hole sizes shall be used. (Standard hole diameters are nominally 1/16" larger than the nominal bolt diameter.)

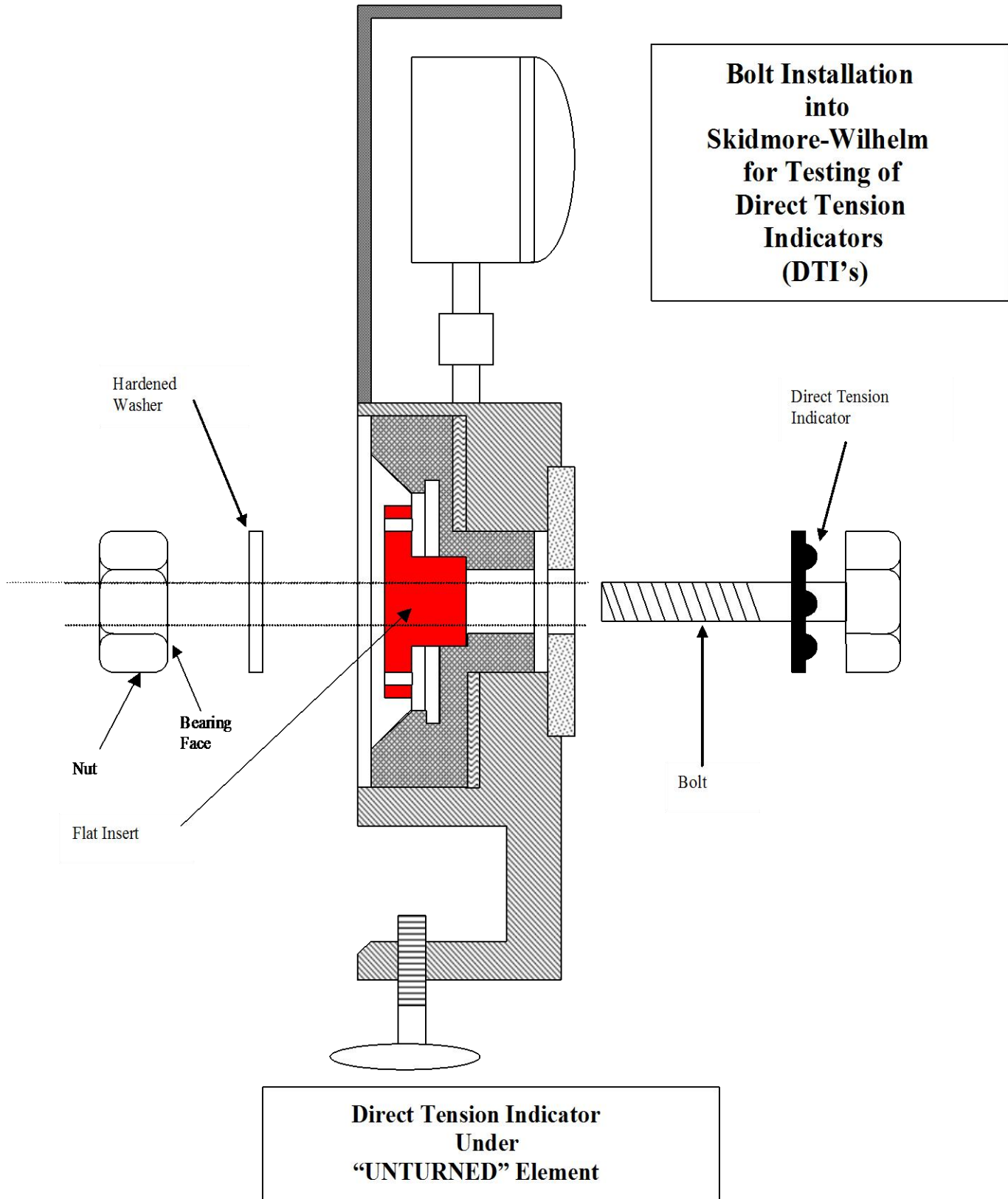


Figure 2

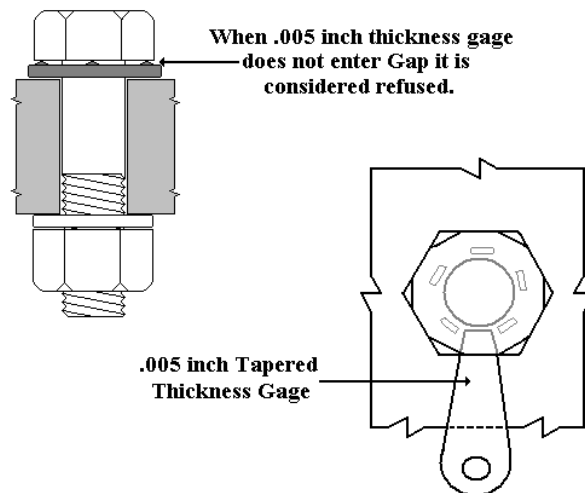
The bolt used for direct tension indicator testing shall be of sufficient length and installed in such a manner that 3 to 5 threads are located behind the bearing face of the nut as shown in figure 2. Shim plates and/or washers (One washer under the nut must always be used) may be required to achieve this arrangement.

- C. Tighten the nut until the bolt tension reading on the dial of the calibrated bolt tension measuring device reaches the minimum required bolt tension, as shown in table 2. Use another wrench on the bolt head to prevent rotation while tightening the nut.

Table 2

Minimum required bolt tension in kips (1 kip = 1000 lbs.)									
Bolt dia. (in.)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
ASTM F3125 Grade A325	13	20	29	41	54	59	75	89	108
ASTM F3125 Grade A490	N/A	N/A	37	51	67	84	107	127	N/A

- D. Determine and record on the DOT-96, the number of spaces between the protrusions on the direct tension indicator for which the .005 inch thickness gage is refused (Does not fit into the space as shown in figure 3). If the number of spaces for which the .005 inch thickness gage is refused is greater than the maximum number specified in table 3, the direct tension indicator fails the verification test.



(Measuring gap with thickness gage)

Figure 3

Table 3

Verification criteria					
	No. of spaces on DTI				
	4	5	6	7	8
Max. No. of spaces refused: <ul style="list-style-type: none"> All plain DTI's Coated* DTI's under "Unturned" element 	1	2	2	3	3
Max. No. of spaces refused: <ul style="list-style-type: none"> Coated* DTI's under "Turned" element 	3	4	5	6	7

* Coated direct tension indicators (DTI's) are defined as galvanized or epoxy coated.

NOTE: Unless otherwise specified on the plans, the South Dakota Standard Specifications for Roads and Bridges require galvanized DTI's. Epoxy coated DTI's are sometimes specified for use on weathering steel structures. Plain DTI's are almost never allowed.

E. The bolt shall be further tightened until the .005 inch thickness gage is refused at all spaces, but a visible gap exists in at least one of the spaces.

NOTE: The test is not valid if the bolt is tightened to a condition in which there is no visible gap. If this occurs, the test will need to be performed again using a new assembly.

Record the bolt tension reading on the dial of the calibrated bolt tension measuring device on the DOT-96. This tension must be less than or equal to the bolt tensile strength given in table 4.

Table 4

Bolt tensile strength in kips (1 kip = 1000 lbs.)									
Bolt dia. (in.)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
ASTM F3125 Grade A325	17	27	40	55	73	80	102	121	148
ASTM F3125 Grade A490	N/A	N/A	50	69	91	114	145	173	N/A

If the recorded tension is more than the bolt tensile strength shown, the direct tension indicator assembly fails the verification test.

F. Remove the bolt assembly from the bolt tension measuring device. Turn the nut onto the full length of the threads of the bolt, excluding the thread runout, by hand. If this can be done, the direct tension indicator has passed the test. If it is not possible to hand turn the nut

onto the full length of the threads of the bolt, excluding thread runout, the direct tension indicator fails the verification test unless the following criteria is met.

If the bolt tension reading recorded in Section 3.1.E is less than 95% of the average load measured in Section 3.1 G, the rotational capacity test (SD 507) for the bolt assembly lot, the direct tension indicator assembly passes this portion of the test.

The results should be recorded on the DOT-96.

If any one of the three direct tension indicators fails the verification test, the lot of DTI's is considered to be in non-compliance with the specifications and should not be allowed to be used in the work.

Bolts, nuts, washers, and direct tension indicators used for testing shall not be incorporated into the work.

3.2 Short bolts.

- A. Using the additional direct tension indicators and the long bolts as per section 2.3.A, perform the testing using the procedures in sections 3.1.A through 3.1.D.
- B. Remove the direct tension indicator assembly from the calibrated bolt tension measuring device.
- C. Using a new direct tension indicator assembly with the short bolt and a new direct tension indicator, install the bolt, nut, washer and direct tension indicator into a steel section or in a joint in the project material. The bolt hole used must be a standard sized hole defined as nominally 1/16" larger than the nominal bolt diameter. The assembly shall be installed into the steel section in the same configuration as it is to be used in the work.
- D. The bolt shall be tightened until the .005 inch feeler gage is refused in all spaces, but a visible gap exists in at least one of the spaces.

NOTE: The test is not valid if the bolt is tightened to a condition in which there is no visible gap. If this occurs, the test will need to be performed again using a new assembly.

- E. Remove the direct tension indicator assembly from the bolt tension measuring device. Turn the nut onto the full length of the threads of the bolt, excluding the thread runout, by hand. If this can be done, the direct tension indicator assembly has passed the test. If it is not possible to hand turn the nut onto the full length of the threads of the bolt, excluding thread runout, the direct tension indicator assembly

fails the verification test. The results should be recorded on the DOT-96.

If any one of the three direct tension indicator assemblies fails the verification test, the DTI lot is considered to be in non-compliance with the specifications and should not be allowed to be used in the work.

Bolts, nuts, washers, and direct tension Indicators used in the testing shall not be incorporated into the work.

4. Report:

A. Report results of the testing as required by this procedure on the DOT-96.

5. References:

ASTM F3125
ASTM F959
SD 507
DOT-96

DIRECT TENSION INDICATORS (DTI)

Project No. P 0019(20)00 County Clay PCN 238H
 Test No. 01 Tested By Brian Hipple Date 09/07/2014

All Section References to SD 503
 Reference Sec. 3.1.A

Size of Bolt: 3/4" Length of Bolt: 3 1/2" Heat/Lot #: M2001 Mfg.: Bennett Finish: Galvanized
 Size of DTI (Nominal Diameter): 3/4" Type (Circle One): A325 A490
 Finish (Circle One): Plain Galvanized Epoxy Coated
 Heat / Lot No. 125865A Manufacturer Wrought
 No. of Spaces on DTI: 5 No. of Spaces Per Table 1: 5

NOTE: If the number of spaces on the DTI's are not the same as shown in Table 1, the DTI's are not acceptable for use.

Reference Sec. 3.1.C

Minimum Required Bolt Tension from Table 2: 29,000 Lbs.

Tension in Table 2 is in kips. To convert to pounds (Lbs.) multiply value from Table 2 by 1000.

Reference Sec. 3.1.D

DTI	No. of spaces .005" Thickness Gage Refused at Min. Tension (A)	Max. Allowable Spaces Refused (B)	Is (A) ≤ (B) (Circle One)
#1	0	2 Spaces From Table 3	<u>YES</u> (Pass) NO (Fail)
#2	0		<u>YES</u> (Pass) NO (Fail)
#3	0		<u>YES</u> (Pass) NO (Fail)

Reference Sec. 3.1.E (Long Bolts)

Reference Sec. 3.1.D (Short Bolts)

DTI	Bolt Tension Reading (When all spaces refused & at least one visible gap) (A)	Min. Bolt Tensile Strength (B)	Is (A) ≤ (B) (Circle One)
#1	39,000 (lbs)	40,000 (lbs) From Table 4	<u>YES</u> (Pass) NO (Fail)
#2	39,500 (lbs)		<u>YES</u> (Pass) NO (Fail)
#3	39,000 (lbs)		<u>YES</u> (Pass) NO (Fail)

DTI	Was it possible to tighten the bolt to a point where the .005" thickness gage is refused at all spaces, but such that a visible gap exists in at least one space without causing damage to the bolt? (Circle One)	
#1	<u>YES</u> (Pass)	NO
#2	YES (Pass)	<u>NO</u>
#3	<u>YES</u> (Pass)	NO

* If the nut cannot be hand-turned onto the bolt excluding thread runout for any of the three bolts, the criteria in 3.1.F must be met.

Reference Sec. 3.1.F

Average Measured Bolt Tension from 3.1.G of the Rotational Capacity Test SD 507 (A)	95% of Avg. Meas. Bolt Tension (A x 0.95) (B)	DTI Assembly	Bolt Tension Reading from 3.1.E (C)	Is (C) ≤ (B) (Circle One)
42,567	40,438	#1	N/A	<u>YES</u> (Pass) NO Fail
		#2	39,500	<u>YES</u> (Pass) NO Fail
		#3	N/A	<u>YES</u> (Pass) NO Fail

Note if there are any signs of stripping or if the nuts could not be run on the threads by hand for any of the three bolts: _____

RESULTS: If the DTI Assemblies failed any of the above Pass/Fail criteria, the DTI Assemblies should not be accepted. (Circle One)

ACCEPTED

REJECTED

(OVER)

Example 1

ROTATIONAL CAPACITY TEST

Project No. _____ County _____ PCN _____

Test No. _____ Tested By _____ Date _____

All Section References to SD 507

Bolt Length: _____ Heat/Lot No. _____
 Bolt Diameter: _____ Manufacturer _____

Reference Section 3.1 (Long Bolts)

Bolt	Reference Sec. 3.1.D Required Initial Tension on Bolt from Table 1 (Kips)	Reference Sec. 3.1.D Measured Initial Tension on Bolt (Kips)	Reference Sec. 3.1.F Measured Bolt Tension (P) at Required Tension (Lbs) (See Table 1 - SD 507)	Reference Sec. 3.1.F Measured Torque at Required Tension (Ft-Lbs) (See Table 2 - SD 507)	Reference Sec. 3.1.G Measured Bolt Tension (P) at Required Rotation (Lbs) (See Table 3 - SD 507)
#1					
#2					
#3					

Tension in Table 1 is in Kips, to convert to pounds (Lbs.) multiply value in Table 1 by 1000.

Reference Section 3.1.H

BOLT	Did the bolt show any signs of stripping or fracture upon visual inspection? (Circle One)		If the bolt or nut show any signs of stripping or fracture, the assembly fails the rotational capacity test. Note any evidence of stripping/fracture. (If YES - See SD 507, Table 5) ----- -----
#1	YES (Fail) (See Table 5)	NO	
#2	YES (Fail) (See Table 5)	NO	
#3	YES (Fail) (See Table 5)	NO	

BOLT	Was the measured bolt tension equal to or greater than the tension required in Table 4? (Circle One)		If the bolt tension is less than the tension in Table 4, the bolt assembly fails the rotational capacity test. (If NO - See SD 507, Table 6)
#1	YES	NO (Fail) (See Table 6)	
#2	YES	NO (Fail) (See Table 6)	
#3	YES	NO (Fail) (See Table 6)	

BOLT	Calculated Maximum Torque (Tmax)	Is the Torque less than or equal to the calculated maximum torque (Tmax)? (Circle One)		If the measured torque is greater than the calculated maximum torque, the assembly fails the rotational capacity test.
#1		YES	NO (Fail)	
#2		YES	NO (Fail)	
#3		YES	NO (Fail)	

RESULTS: If the bolt assemblies failed any of the above tests, the assembly fails the rotational capacity test. (Circle One)

ACCEPTED

REJECTED

Reference Section 3.2 (Short Bolts)

Reference Sec. 3.2.F

BOLT	Measured Torque at Required Rotation (Ft.-Lbs.)
#1	
#2	
#3	

Reference Section 3.2.G

BOLT	Did the bolt or nut show any signs of stripping or fracture upon visual inspection? (Circle One)		If the bolt or nut shows any signs of stripping or fracture, the assembly fails the rotational capacity test. Note any evidence of stripping/fracture. ----- -----
#1	YES (Fail)	NO	
#2	YES (Fail)	NO	
#3	YES (Fail)	NO	

BOLT	Calculated Maximum Torque (Tmax)	Is the Torque less than or equal to the calculated maximum torque (Tmax)? (Circle One)		If the measured torque is greater than the calculated maximum torque, the assembly fails the rotational capacity test.
#1		YES	NO (Fail)	
#2		YES	NO (Fail)	
#3		YES	NO (Fail)	

RESULTS: If the bolt assemblies failed any of the above tests, the assembly fails the rotational capacity test. (Circle One)

ACCEPTED

REJECTED