

Procedures for Rotational Capacity Testing for High Strength Bolts

1. Scope:

The rotational capacity test is designed to evaluate the presence and efficiency of a lubricant on the nut, and the compatibility of the bolt assemblies as represented by the components selected for testing such that, when installed, the desired bolt tension is achieved without excessive plastic deformation.

This procedure may be applied to all bolts requiring rotational capacity testing regardless of length. A separate procedure is provided for long and short bolts. A long bolt is defined as any bolt with adequate length to be properly installed in a calibrated bolt tension measuring device. A short bolt is defined as any bolt that is too short to be tested in the device.

2. Apparatus:

2.1 Rotational capacity of long bolts.

- A. Calibrated bolt tension measuring device: (Skidmore-Whilhelm or other approved device).
- B. Calibrated torque wrench.
- C. Hand wrench.
- D. Protractor.
- E. Bolts, nuts, and washers.
 - a. Three assemblies for each diameter and length of bolt are required. If bolts of the same diameter and length are supplied from more than one lot, three assemblies are required for each lot.
 - b. The 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.

2.2 Rotational capacity of short bolts.

- A. Steel section with standard size hole (Standard hole diameters are nominally 1/16" larger than the nominal bolt diameter.) In lieu of providing a steel section for this testing, the bolts may be tested in a steel joint in the project material.
- B. Calibrated torque wrench.

- C. Hand wrench.
- D. Protractor.
- E. Bolts, nuts, and washers.
 - a. Three assemblies for each diameter and length of bolt are required. If bolts of the same diameter and length are supplied from more than one lot, three assemblies are required for each lot.
 - b. The 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.

3. Procedure:

3.1 Determining rotational capacity of long bolts.

- A. Mark off a vertical line on the face plate of the calibrated bolt tension measuring device. Using a protractor, mark off additional lines at 120 degrees, and 240 degrees as shown in figure 1.

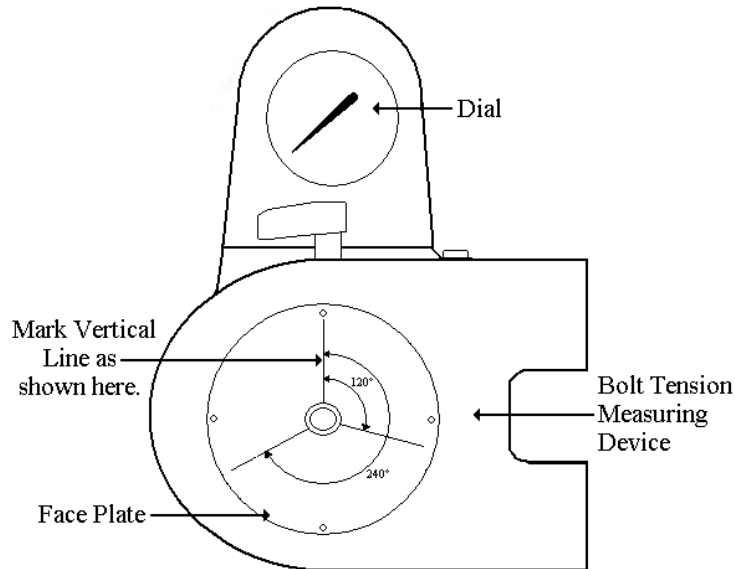


Figure 1

- B. Measure the length (L) and diameter (D) of the bolt and record the information on the DOT-96. See figure 2.

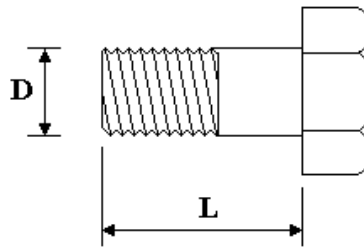


Figure 2

- C. The bolt, nut, and washer shall be assembled into the calibrated bolt tension measuring device as shown in figure 3. Face plates, bolt rotation prevention inserts (If available), and spacers with standard holes shall be used. (Standard hole diameters are nominally 1/16" larger than the nominal bolt diameter.) The bolt shall be of sufficient length and installed utilizing sufficient shim plates and/or washers (One washer under the nut must always be used) such that 3 to 5 threads are located behind the bearing face of the nut as shown in figure 3.
- D. Tighten the bolt using a hand wrench to achieve a snug tension within the range specified in table 1 for the diameter of the bolt being tested. Record the measured initial bolt tension on the DOT-96.

Table 1

Bolt dia. (Inch)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Snug tension (Kips)	1 to 3	2 to 4	3 to 5	4 to 6	5 to 7	6 to 8	7 to 9	9 to 11	10 to 12

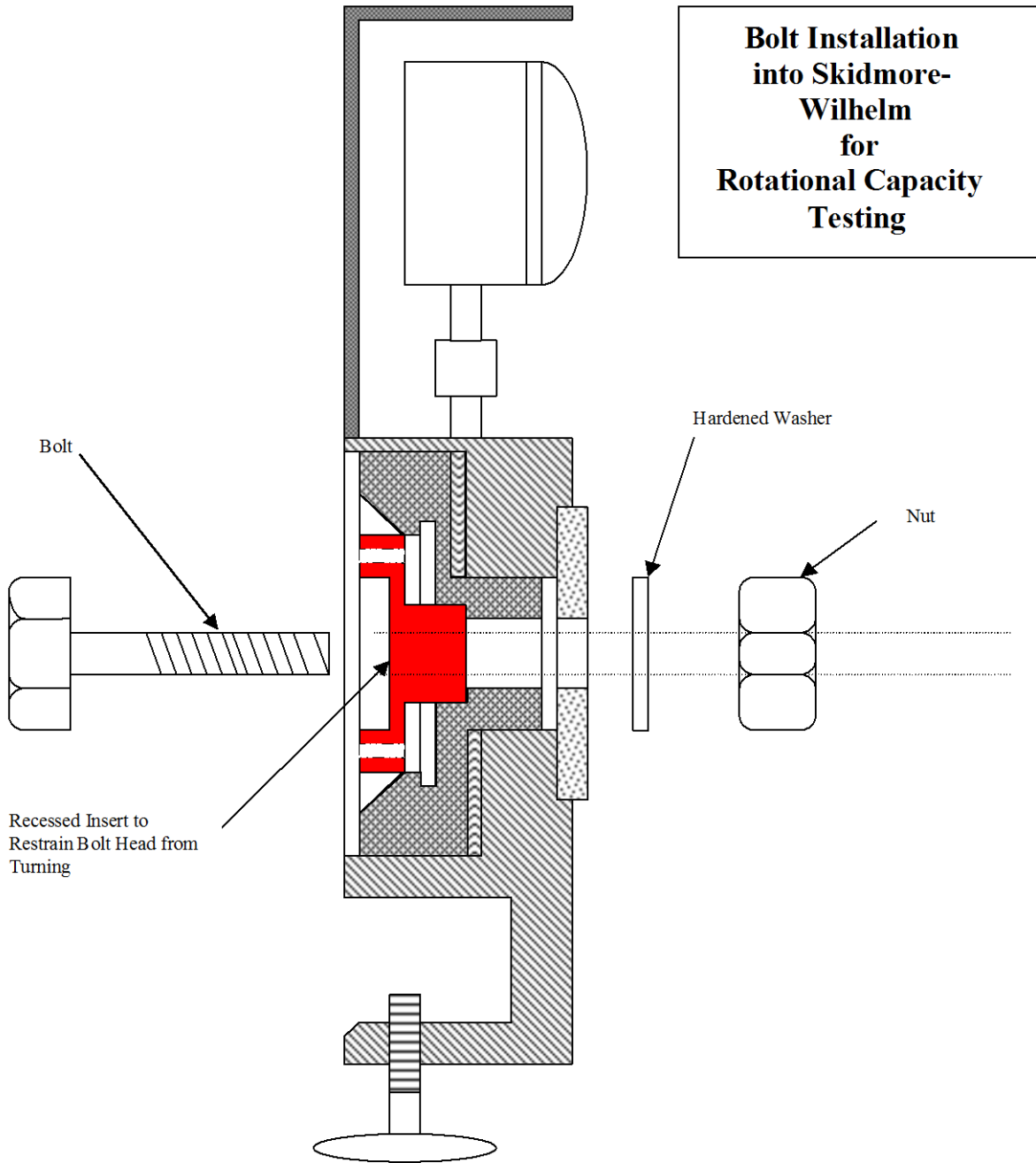


Figure 3

- E. Match mark the nut to the vertical line marked on the face plate in 3.1.A as shown below in figure 4. (It may facilitate testing if the wrench socket is also match marked to the vertical line on the face plate.)

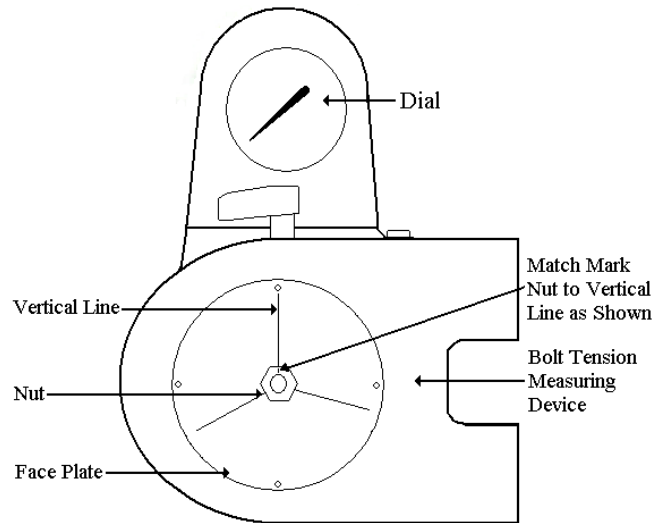


Figure 4

- F. Using a calibrated torque wrench, tighten the “Nut” to the tension as specified in table 2. Obtain the bolt tension (P) from the dial of the device and the torque (T) from the wrench and record these values on the DOT-96.

NOTE: The torque must be measured with the nut in motion.

The head of the bolt shall not be allowed to rotate during this tightening. The bolt tension measuring device may have an insert that will prevent the head of the bolt from rotating, but if not, a hand wrench may be required.

Table 2

Bolt size (Inches)	Required installation tension (Pounds)
1/2	12,000
5/8	19,000
3/4	28,000
7/8	39,000
1	51,000
1-1/8	56,000
1-1/4	71,000
1-3/8	85,000
1-1/2	103,000

- G. Further tighten the "Nut" to the rotation as specified in table 3. The rotation of the nut should be measured from the vertical line marked in 3.1.A and the initial match mark made in 3.1.E.

NOTE: The head of the bolt shall not be allowed to rotate during this tightening. The bolt tension measuring device may have an insert that will prevent the head of the bolt from rotating, but if not, a hand wrench may be required.

Table 3

Bolt length	Required rotation
Less than or equal to 4 times the bolt diameter.	2/3 rotation (240°)
Greater than 4 times the bolt diameter and less than or equal to 8 times the bolt diameter.	1 rotation (360°)
Greater than 8 times the bolt diameter	1 1/3 rotations (480°)

Obtain the bolt tension (Pmax) from the dial of the device at the specified rotation and record these values on the DOT-96.

Loosen the nut and remove the bolt assembly from the bolt tension measuring device. Visually inspect the bolt assembly for evidence of stripping or fracture and record the information on the DOT-96.

H. Acceptance criteria: The bolt and nut assembly is considered to be in conformance if all of the following requirements are met:

1. If the visual inspection as per 3.1.G shows no signs of stripping or fracture the bolt assembly meets the requirements. If signs of stripping or fracture are visible, the bolt assembly fails the rotational capacity test. Some minor amount of stretch is expected to occur between the face of the nut and the bolt head and does not constitute failure of the test.
2. If the bolt tension (Pmax) measured in 3.1.G is equal to or greater than the tension required in table 4 below the bolt assembly meets the requirements.

If the measured bolt tension is less than the tension required in table 4 the bolt assembly fails the rotational capacity test.

Table 4

Bolt dia. (Inch)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Tension (Kips)	14	22	32	45	59	64	82	98	118

3. The torque (T) measured in 3.1.F is less than or equal to the maximum torque (T_{max}), which is calculated as follows:

$$T_{\max} = 0.25 P (D/12)$$

Where:

T_{max} = Maximum torque in ft.-lbs.

P = Bolt tension (Measured in 3.1.F) in pounds.

D = Bolt diameter in inches.

If the Torque (T) measured in 3.1.F is greater than the maximum torque (T_{max}) the bolt assembly fails the rotational capacity test.

Failure of the rotational capacity test does not necessarily mean that the bolts, nuts, and washers represented cannot be used in the work. It is possible that the nuts may be dry or were improperly lubricated. The nuts may be sent back to the supplier to be re-lubricated and the rotational capacity test re-run. If the assembly still fails the rotational capacity test, then the bolt assemblies should not be allowed for use.

3.2 Determining rotational capacity of short bolts

- A. Mark off a vertical line from the center of the bolt hole on the steel section or in a steel joint in the project material. Using a protractor, mark off additional lines at 120 degrees, and 240 degrees as shown in figure 5.

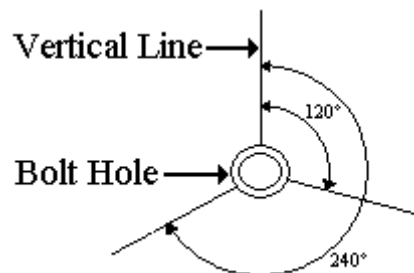


Figure 5

- B. Measure the length (L) and diameter (D) of the bolt and record the information on the DOT-96. See figure 6.

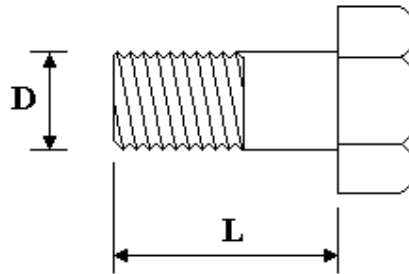


Figure 6

- C. The bolt, nut, and washer shall be assembled into the steel section (Or steel joint from project material) as shown in figure 7. The nut should be placed on the side of the steel section on which the reference lines per 3.2.A were drawn. The bolt shall be of sufficient length and installed utilizing sufficient shim plates and/or washers (One washer under the nut must always be used) such that 3 to 5 threads are located behind the bearing face of the nut as shown in figure 7.

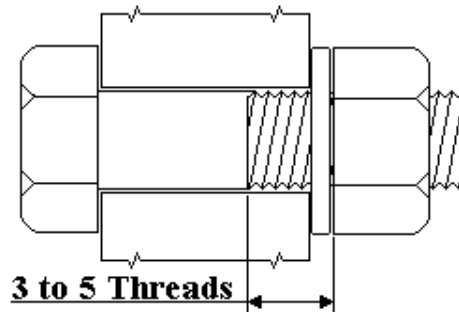


Figure 7

- D. Snug the bolt using a hand wrench. (The snug condition should be the normal effort applied to a 12-inch long wrench.)
- E. Match mark the nut to the vertical line marked on the steel section in 3.2 A as shown below in figure 8. (It may facilitate testing if the wrench socket is also match marked to the vertical line on the face plate.)

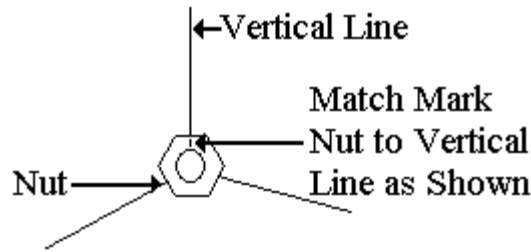


Figure 8

- F. Using a calibrated torque wrench, tighten the “Nut” to the rotation as specified in table 5. The rotation of the nut should be measured from the vertical line marked in 3.2.A and the initial match mark made in 3.2.E.

NOTE: The head of the bolt shall not be allowed to rotate during this tightening.

Table 5

Bolt length	Required rotation
Less than or equal to 4 times the bolt diameter	2/3 rotation (240°)
Greater than 4 times the bolt diameter and less than or equal to 8 times the bolt diameter.	1 rotation (360°)
Greater than 8 times the bolt diameter	1 1/3 rotations (480°)

Obtain the torque (T) from the wrench at the required rotation and record this value on the DOT-96.

NOTE: The torque must be measured with the nut in motion.

Loosen the nut and remove the bolt assembly from the steel section. Visually inspect the bolt assembly for evidence of stripping or fracture and record the information on the DOT-96.

- G. Acceptance Criteria: The bolt and nut assembly is considered to be in conformance if all of the following requirements are met:
1. If the visual inspection as per 3.2.F shows no signs of stripping or fracture, the bolt assembly meets the requirements. If signs of stripping or fracture are visible, the bolt assembly fails the rotational capacity test. Some minor amount of stretch is

expected to occur between the face of the nut and the bolt head and does not constitute failure of the test.

2. The torque (T) measured in 3.2.F is less than or equal to the maximum torque (T_{max}), which is calculated as follows:

$$T_{\max} = 0.25 (P \times 1000) (D/12)$$

Where:

T_{max} = Maximum torque in ft-lbs.

P = Bolt tension obtained from table 6 in kips.

D = Bolt diameter in inches.

If the torque (T) measured in 3.2.F is greater than the maximum torque (T_{max}) the bolt assembly fails the rotational capacity test.

Table 6

Bolt dia. (Inch)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Tension (Kips)	14	22	32	45	59	64	82	98	118

Failure of the rotational capacity test does not necessarily mean that the bolts, nuts, and washers represented cannot be used in the work. It is possible that the nuts may be dry or were improperly lubricated. The nuts may be sent back to the supplier to be re-lubricated and the rotational capacity test re-run. If the assembly still fails the rotational capacity test, then the bolt assemblies should not be allowed for use.

NOTE: Bolts, nuts and washers used for 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 A563
 DOT-96

DIRECT TENSION INDICATORS (DTI)

Project No. _____ County _____ PCN _____

Test No. _____ Tested By _____ Date _____

All Section References to SD 503
Reference Sec. 3.1A

Size of Bolt: _____ Length of Bolt: _____ Heat/Lot #: _____ Mfg.: _____ Finish: _____

Size of DTI (Nominal Diameter): _____ Type (Circle One): A325 A490

Finish (Circle One): Plain Galvanized Epoxy Coated

Heat / Lot No. _____ Manufacturer _____

No. of Spaces on DTI: _____ No. of Spaces Per Table 1: _____

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: _____ 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		Spaces	YES (Pass) NO (Fail)
#2			YES (Pass) NO (Fail)
#3			From Table 3 YES (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	(lbs)	(lbs)	YES (Pass) NO (Fail)
#2	(lbs)		YES (Pass) NO (Fail)
#3	(lbs)		From Table 4 YES (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	YES (Pass)	NO
#2	YES (Pass)	NO
#3	YES (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)
		#1		YES (Pass) NO Fail
		#2		YES (Pass) NO Fail
		#3		YES (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. P 0019(20)00 County Clay PCN 238H

Test No. 02 Tested By Brian Hipple Date 09/07/2014

All Section References to SD 507

Bolt Length: 3 1/2" Heat/Lot No. M162598
 Bolt Diameter: 3/4" Manufacturer Gerdau

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	3 - 5	4.5	28,000	320	43,000
#2	3 - 5	4.5	28,000	344	42,500
#3	3 - 5	4.5	28,000	271	42,200

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)	<input checked="" type="radio"/> NO	
#2	YES (Fail) (See Table 5)	<input checked="" type="radio"/> NO	
#3	YES (Fail) (See Table 5)	<input checked="" type="radio"/> 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	<input checked="" type="radio"/> YES	NO (Fail) (See Table 6)	
#2	<input checked="" type="radio"/> YES	NO (Fail) (See Table 6)	
#3	<input checked="" type="radio"/> 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	437.5	<input checked="" type="radio"/> YES	NO (Fail)	
#2	445	<input checked="" type="radio"/> YES	NO (Fail)	
#3	437.5	<input checked="" type="radio"/> 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	464
#2	458
#3	452

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)	<input checked="" type="radio"/> NO	
#2	YES (Fail)	<input checked="" type="radio"/> NO	
#3	YES (Fail)	<input checked="" type="radio"/> NO	

Minor stretch on Bolt 1 & 2 - OK

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	500	<input checked="" type="radio"/> YES	NO (Fail)	
#2	500	<input checked="" type="radio"/> YES	NO (Fail)	
#3	500	<input checked="" type="radio"/> 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