



Part 4: Signal Structures

Joanna Bush





Signal Structures

- Type 9, 10, 12 & 13 Structures
- Concrete Bases (Type 10 & 13)
- Anchor Bolt Tensioning
- Connection Hardware Testing





What is a “monotube”?





Why did we change our design?





Structure Types

Type 9/10 Structures

- 15' to 30' mast arms
- Type 10 concrete base
 - SDD 9c11
 - 14' deep
 - 30" diameter
 - 1 ½" anchor rods – 52" length
- 6 sets of 1" high strength bolts for mast arm connection

Type 12/13 Structures

- 35' to 55' mast arms
- Type 13 concrete base
 - SDD 9c12
 - 14' 6" deep
 - 42" diameter
 - Wing extends 4' out from base
 - 1 ¾" anchor rods – 86" length
- 8 sets of 1 ½" high strength bolts for mast arm connection





Concrete Base (Type 10 or 13) Basics

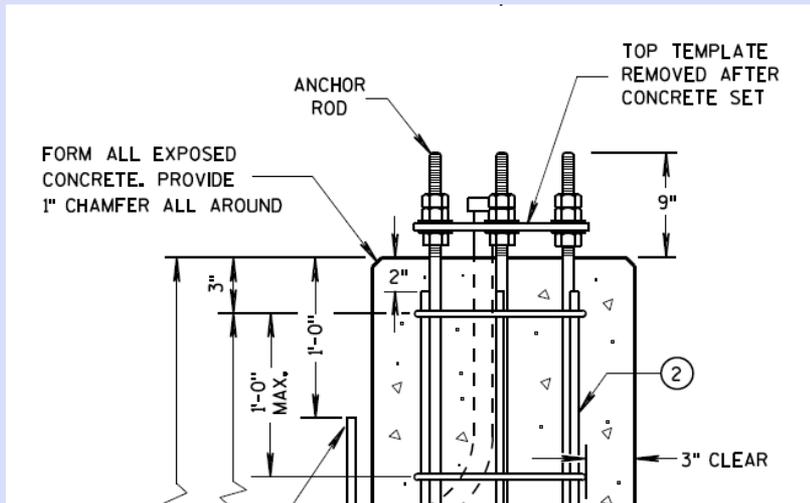
- Sonotube cannot be left in place. After it is removed, soil must be compacted in 1-foot lifts.
- Construction joints require written approval by engineer (must consult BOS).
- Top template must be removed after concrete sets (stabilizes anchor bolts during pour and provides guidance for arm orientation).
- Concrete must attain 3500 psi compressive strength before structure can be erected (7 days).



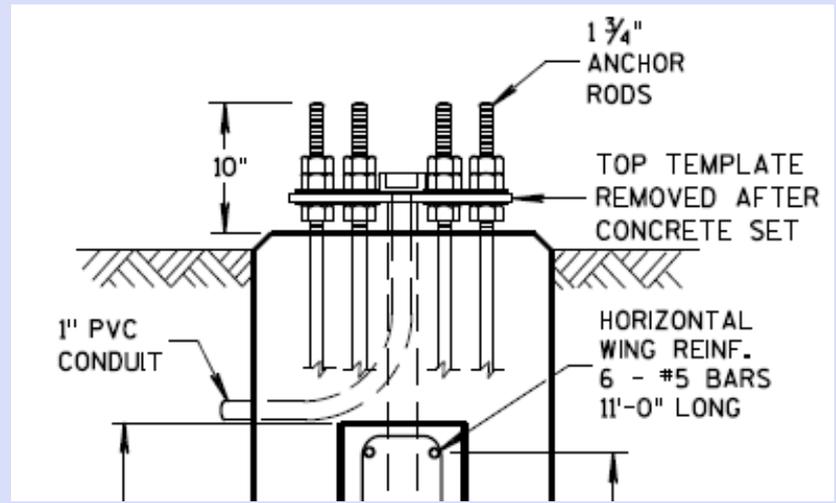


Bolt Projections

Type 10



Type 13





Material Responsibilities

WisDOT

- Poles
- Arms
- Anchor Bolts
- Templates

Contractor

- Arm connection hardware (incl. luminaire arms)
- Identification plaque





Standing the Structure





Anchor Bolt Tensioning – Form DT 2321



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Step 3 Lubricate (wax based) anchor rods (within 24 hours of tensioning) and turn nut down to foundation—this should run freely with little resistance \approx 20 ft.-lbs. or less.	Was wax based lubrication applied and did leveling nut run down freely?	<input type="checkbox"/>	<input type="checkbox"/>
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Step 8 Install Jam nuts if shown on shop drawings.	Were Jam nuts installed correctly per Table 1? (answer only if Jam nuts are required)	<input type="checkbox"/>	<input type="checkbox"/>



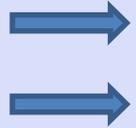


Step One – Verify Anchor Rods





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Step 2 – Plumb





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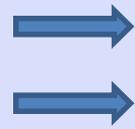
Step 3 – Lubricant (wax based)





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Step 4 – Level Leveling Nuts





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Anchor Bolt Tensioning – Form DT 2321

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2 3/4	1,221 to 1,832	6,716	305
2 1/2	900 to 1,350	4,950	225
2 1/4	657 to 986	3,614	164
2	452 to 678	2,486	113
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1 1/8	77 to 115	421	25
1	54 to 81	297	25
7/8	37 to 55	202	25
3/4	23 to 34	124	25

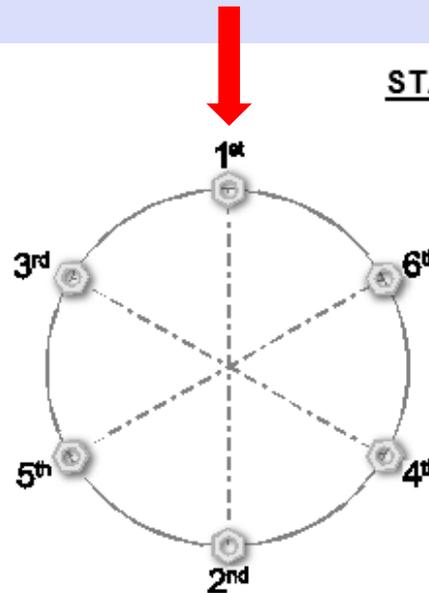


Figure 1

STAR PATTERN

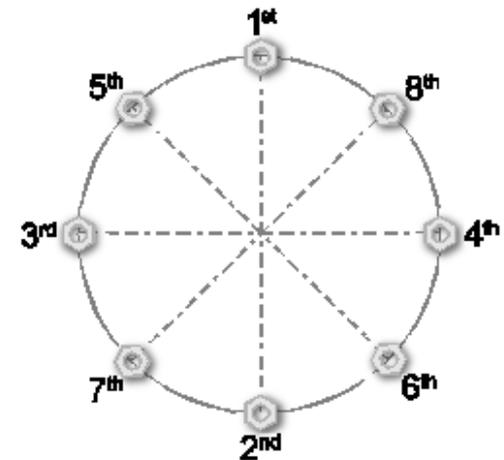


Figure 2





Step 5 – Tools for the Job

Manual Torque Wrench



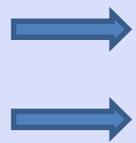
Electric Torque Wrench





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Match Marking





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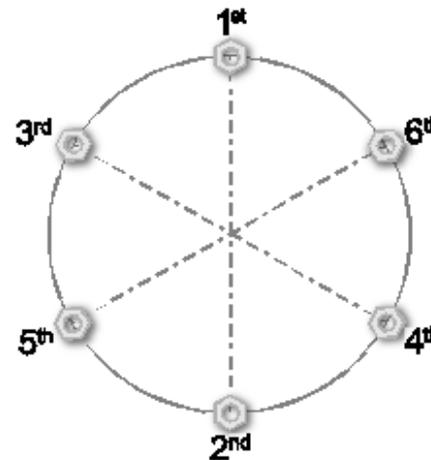


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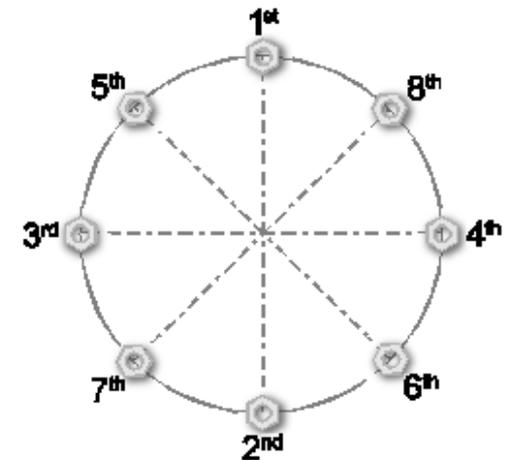


Figure 2





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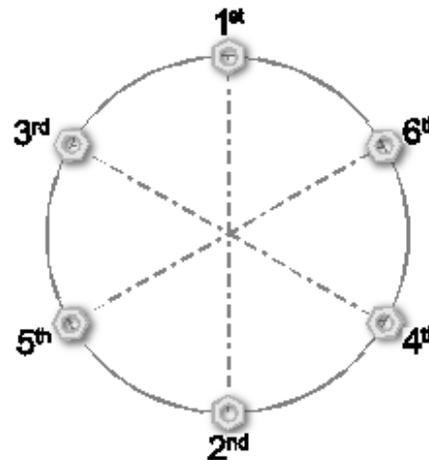


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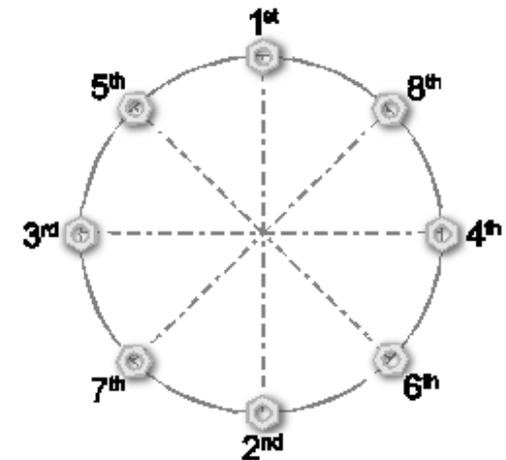


Figure 2





Arm Connection





Connection Hardware

- A325 Bolts only
 - Stored in an air tight container
- Required Documentation
 - Bolt Certs
 - Rotational Capacity Test Results
- Direct Tension Indicators (DTIs)
- Required Testing
 - Mechanical Testing
 - Pre-Installation Testing





Hardware Certification

This certifies that the following product that we have galvanized for your company meets the specifications of ASTM A153, Class C and the hot dip galvanizing requirements of ASTM F2329.

The hot dip galvanizing is RoHS compliant. The galvanizing process was conducted in a temperature range of 830F to 850F.

This certification in no way implies anything other than the quality of our hot dip galvanizing as it pertains to your order.

This product was galvanized in Rockford, IL USA

46,669 pieces	P1383HP300	5/8" F436 Structural Washer	Lot#C6339	6.05 Avg. Mils
46,094 pieces	P1383HP300	5/8" F436 Structural Washer	Lot#C6339	5.50 Avg. Mils
46,105 pieces	P1383HP300	5/8" F436 Structural Washer	Lot#C6339	4.20 Avg. Mils
20,123 pieces	P2067MP300	3/4" USS Washer	Lot#C6242	3.41 Avg. Mils
26,492 pieces	P2067MP300	3/4" USS Washer	Lot#C6242	4.10 Avg. Mils
20,470 pieces	P1900HP300	1" F436 Structural Washer	Lot#C6495	4.19 Avg. Mils
19,639 pieces	P1900HP300	1" F436 Structural Washer	Lot#C6495	4.82 Avg. Mils
28,186 pieces	P1700HP300	7/8" F436 Structural Washer	Lot#C6536	2.57 Avg. Mils
27,676 pieces	P1700HP300	7/8" F436 Structural Washer	Lot#C6536	
28,239 pieces	P1700HP300	7/8" F436 Structural Washer	Lot#C6536	
13,917 pieces	P1700HP300	7/8" F436 Structural Washer	Lot#C6536	
14,959 pieces	P1700HP300	7/8" F436 Structural Washer	Lot#C6536	
25,955 pieces	P1700HP300	7/8" F436 Structural Washer	Lot#C6547	
28,567 pieces	P1700HP300	7/8" F436 Structural Washer	Lot#C6547	
26,060 pieces	P1700HP300	7/8" F436 Structural Washer	Lot#C6547	
8,424 pieces	F3015HP300	1-1/2" F436 Structural Washer	Lot#C5378	
4,441 pieces	F3015HP300	1-1/2" F436 Structural Washer	Lot#C5378	
7,694 pieces	F3015HP300	1-1/2" F436 Structural Washer	Lot#C5378	
28,962 pieces	F1700HP300	7/8" F436 Structural Washer	Lot#C6536	
19,586 pieces	F1700HP300	7/8" F436 Structural Washer	Lot#C6536	
29,558 pieces	F1700HP300	7/8" F436 Structural Washer	Lot#C6536	

Mill Cert

Description: .136 x 3.250 x coil

Part#: F3015H00 Mid-State Coil #: R24406 Master Coil#: 1684660

Material chemical weight percent composition:

The chemical analysis hereby reported was supplied by the producing mill and provided certification is maintained in the records of the corporation.

Heat #: 124222 Grade: 1050 PO: 19869

Carbon: 0.53 Manganese: 0.65

Phosphorus: 0.010 Sulfur: 0.006

Silicon: 0.229 Aluminum: 0.028

Rockwell: 90

Galvanizing





Rotational Capacity Test



ROTATIONAL CAPACITY TEST/RECORD

Wisconsin Department of Transportation
DT2113 9/2013

This form should be completed and filed with the as-built construction as a permanent record. One worksheet shall be completed for each rotational capacity lot number used on the project. A lot shall consist of any possible combination of nut and bolt to be used in the intended structure. This test is required prior to the start of bolt installation work on the project site.

Region []	Contract Number []
Job Number []	Project []
Bolt Grade <input type="checkbox"/> A325 <input type="checkbox"/> A490	Assigned R-C Lot Number []

Rotational Capacity Test Instructions (tables on back)

- Insert fastener assembly into a load cell¹⁾ and tension according to Table 5.
- Match mark the nut and plate on the load cell, and turn until tension is at or above the Table 2.
- Record tension on Line 1.
- Record the torque on Line 2²⁾.
- Compare torque on Line 2 with Table 4—torque should be less than the listed maximum when at tension on Line 1.
- Continue turning the nut, until reaching the total rotation of Table 1 and record the tension on Line 4.
- Compare tension on Line 4 with Table 3 and verify that it passed on Line 5.
- Loosen nut and examine assembly. Nuts should turn on by hand to the point tightened.
- Failure of any portion of the test in either of the two assemblies constitutes a failure of the test as listed below. When failure occurs, the subject lot of fasteners is rejected. The contractor is given the option to clean and re-lubricate as necessary and resubmit for testing.
 - Exceeding maximum allowable torque/tension (Table 4).
 - Failure to achieve the required rotation (Table 1).
 - Failure to achieve the required tension at the required rotation (Table 3).
 - Thread failure—will not turn on by hand, shear cracks, stripping or torsional failures.

¹⁾ For short bolts that won't fit the load cell use a plate with a hole and skip the tension requirements.

²⁾ Measure torque while nut is turning.

	Bolt	Nut	Washer
Manufacturer	[]	[]	[]
Lot Number	[]	[]	[]
Diameter/Length	[] Inches	[]	[]

Rotational Capacity Test Record	Sample #1	Sample #2
1. Measured tension at or above minimum in Table 2	[] Kips	[] Kips
2. Measure torque after step 1	[] Ft/Lbs	[] Ft/Lbs
3. Torque was less than maximum allowable from Table 4	<input type="checkbox"/> Pass <input type="checkbox"/> Fail	<input type="checkbox"/> Pass <input type="checkbox"/> Fail
4. Measured tension* (after total rotation in Table 1)	[] Kips	[] Kips
5. Measured tension is above minimum allowable Table 3	<input type="checkbox"/> Pass <input type="checkbox"/> Fail	<input type="checkbox"/> Pass <input type="checkbox"/> Fail
6. Verify thread condition	<input type="checkbox"/> Pass <input type="checkbox"/> Fail	<input type="checkbox"/> Pass <input type="checkbox"/> Fail

*Applies to long bolts test only, leave blank for short bolts

Tested By []	Witnessed By []
Location []	Date (m/d/yyyy) []





Mechanical Testing

- Send two bolts (with 4 flat washers and 3 nuts)
- Do not include DTI washers – will simply be thrown away
- DT 1499
- Results will be posted in Highway Quality Management System

Test Number: 0 - 115 - 0125 - 2016		Lab Site Page 1 of 1
Materials Laboratory Testing System Tests On: High Strength Bolts, Nuts and Washers Type: V - VERIFICATION		Wisconsin Department of Transportation Bureau of Technical Services-Central Lab Truax Center, 3502 Kinsman Blvd. Madison, WI 53704
Main Project ID: 1009-00-83 Fond du Lac Bypass STH 23 - USH 151 USH 151		Qty Represented: Units Represented:
Date Received: 05/28/16 By: NE REGION	Date Tested: 06/07/16 By: GARY CARLSON	Date Sampled 05/16/16 By: CRAIG CLEMENTS





Pre-Installation Verification Test



ANCILLARY STRUCTURES PRE-INSTALLATION VERIFICATION TEST OF HIGH STRENGTH BOLTS

Wisconsin Department of Transportation

DT2322 2/2015

*This form should be filed with the completed project file as a permanent record. This form should **not** be used for highway bridges.*

PRE-INSTALLATION

Purpose of Test: Establish individual installation requirements for structural fasteners and DTI's by performing and verifying that tension obtained in three samples of each fastener assembly lot is at least 5% above the minimum installation tension. Perform prior to installing fasteners in ancillary structures and record the results along with the fastener assembly lot information.

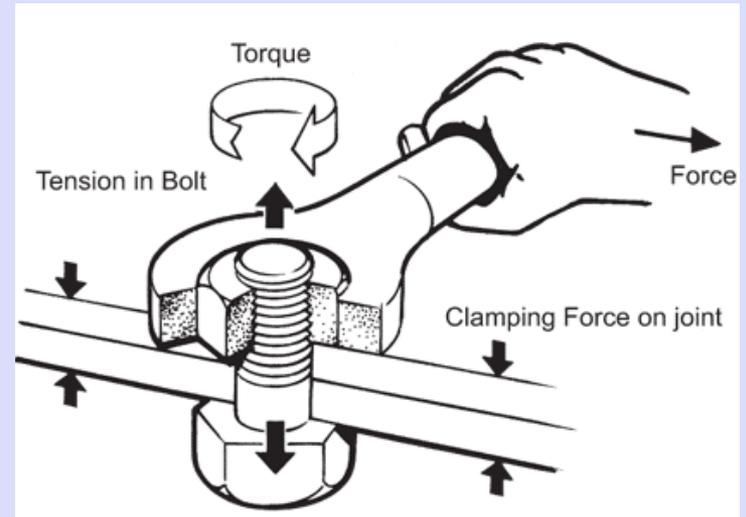




Load Cell



Torque \neq Tension



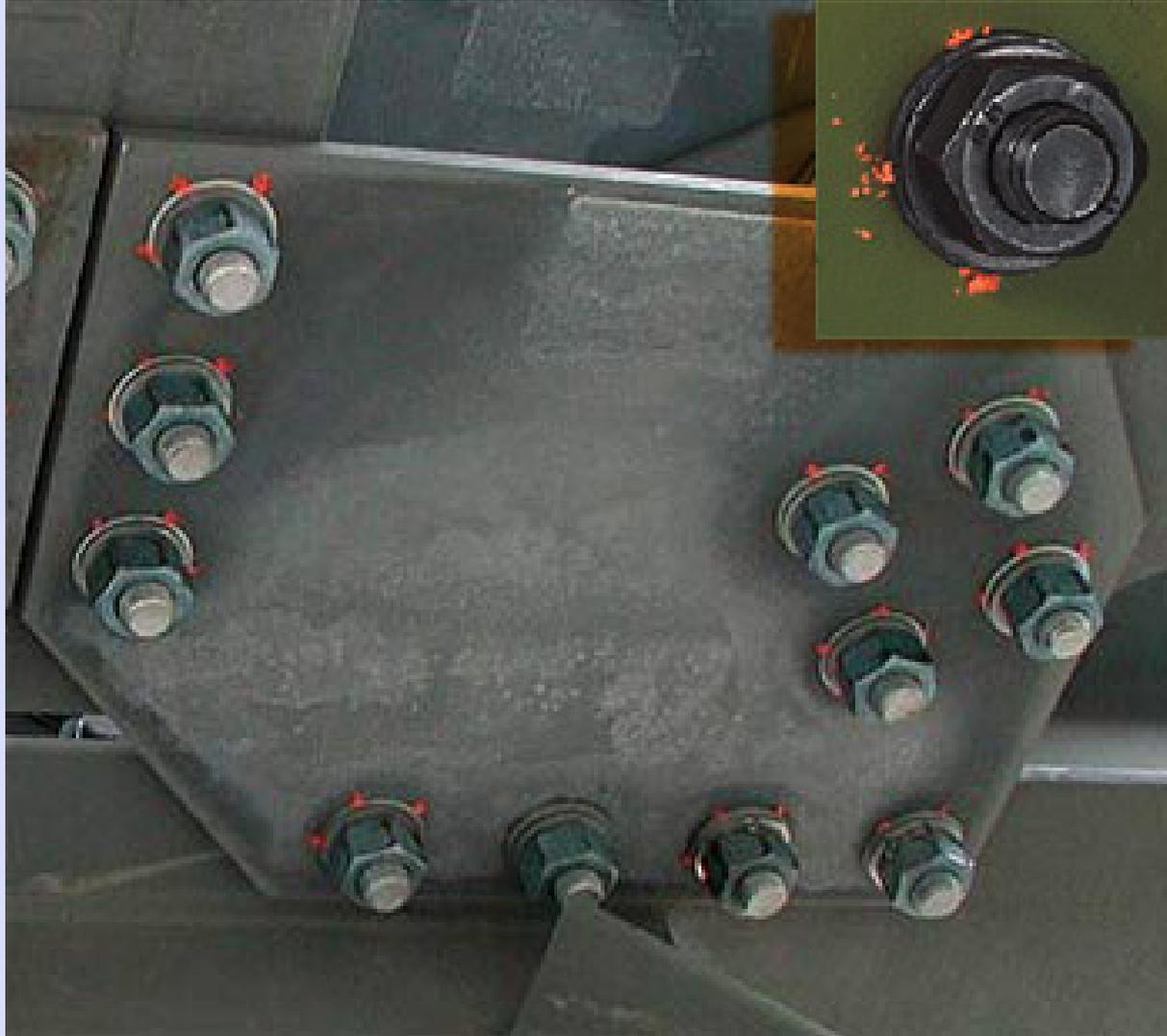


Direct Tension Indicators





"Squirters"





DT 2322

INSTRUCTIONS

1. Fill in the information regarding each lot combination, noting that each combination to be used requires a separate test.
2. Take 3 fastener assemblies (A325 Bolt, A563 Nut, F436 Washer*) from a lot previously tested with a rotational capacity test and ASTM F959 DTI's. Test in the same configuration as the bolts and DTI's are being installed in the structure (note step 8).
3. Lubricate nut (face and threads) with wax based lubricant.
4. Tension with a calibrated torque wrench until reaching the minimum number of refusals from Table 1, measured with a .005" feeler gauge. If 100% refusals are obtained prior to reaching the tension in Table 2, the lot of DTI's fails.
5. Record the measured torque and tension in Table 3.
6. Verify the torque is below the maximum in Table 4 (see page 2) and the tension meets the minimum in Table 2.
7. Repeat steps 3 through 6 and record the information in Table 3 below.
8. Check the configuration used during testing:
 - DTI Under Head, Turn Nut (*preferred*)
 - DTI Under Nut, Turn Nut
 - DTI Under Head, Turn Head
 - DTI Under Nut, Turn Head

*Note: Special washers may be required for larger bolts.





Step 1: Assembly Information

	Bolt	Nut	Washer	DTI
Manufacturer				
Lot Number				
Diameter/Length			Note: Each fastener assembly lot requires a separate worksheet.	





DT 2322

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DTI Under Nut, Turn Nut

DTI Under Head, Turn Head

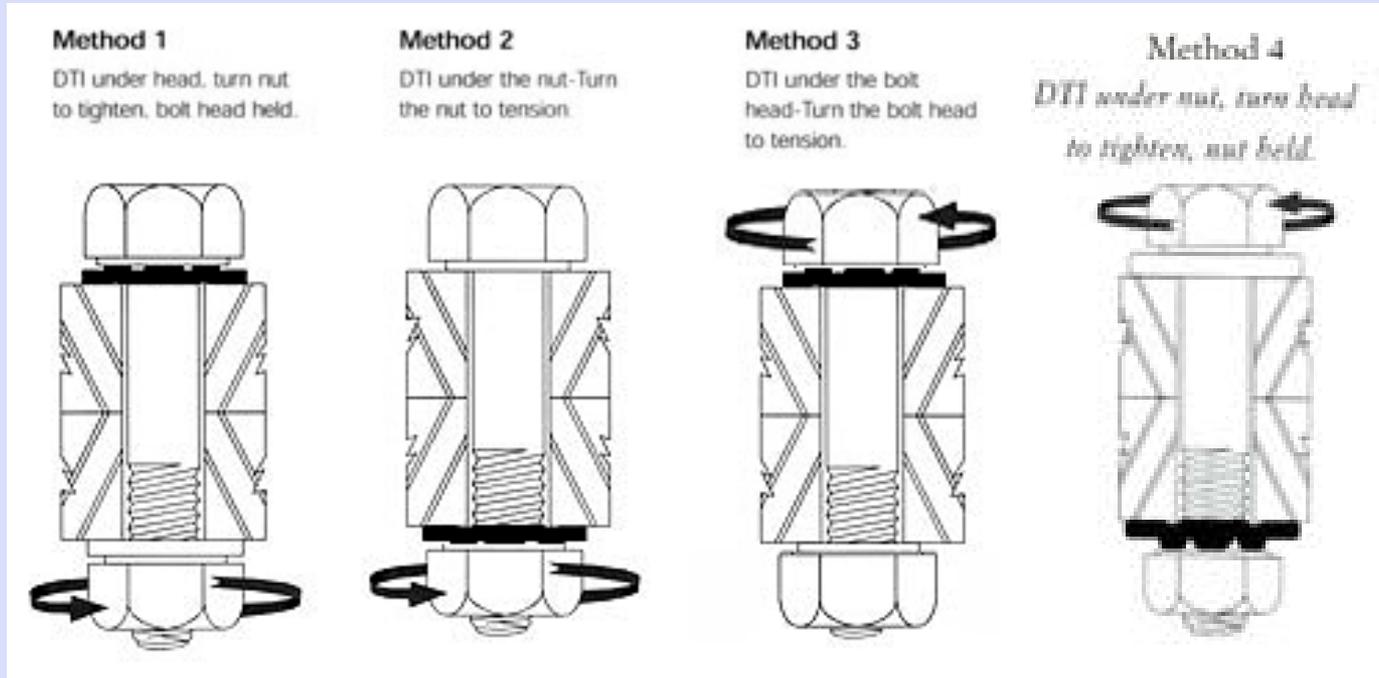
DTI Under Nut, Turn Head

*Note: Special washers may be required for larger bolts.





Step 2: Bolt Configuration



Signal structures require flat washers on BOTH sides of the plates.





DT 2322

INSTRUCTIONS

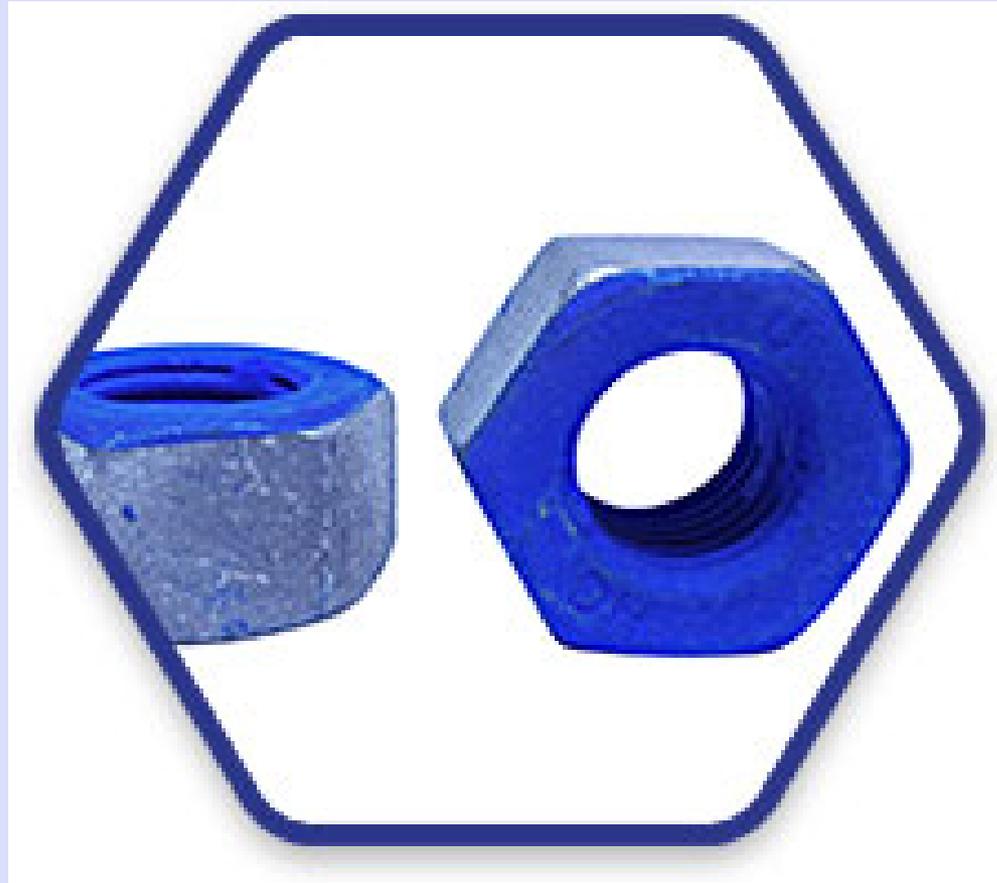
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*Note: Special washers may be required for larger bolts.





Step 3: Lubricate Nut Face & Threads





DT 2322

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 - DTI Under Nut, Turn Head

*Note: Special washers may be required for larger bolts.





DT 2322 – Tables 1 & 2

Type 9/10 Structures

Table 1. DTI Refusals

Number of Gaps	4	5 or 6	7 or 8
Minimum Number of Refusals	2	3	4

Table 2. Minimum Installation Tension Required for the Pre-installation Test

Bolt Dia.	3/4"	7/8"	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"
A325 Kips	29 Kips	41 Kips	54 Kips	59 Kips	75 Kips	89 Kips	108 Kips

Type 12/13 Structures





DT 2322

INSTRUCTIONS

1. Fill in the information regarding each lot combination, noting that each combination to be used requires a separate test.
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 - DTI Under Nut, Turn Nut
 - DTI Under Head, Turn Head
 - DTI Under Nut, Turn Head

*Note: Special washers may be required for larger bolts.





Step 5: Record Measured Values

Table 3.

Sample	Measured Tension	Tension Acquired?	Measured Torque	Torque Below MAX?	Number of Refusals	Refusals Acceptable?
1		<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
2		<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
3		<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
				Average Total:		





DT 2322

INSTRUCTIONS

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 - DTI Under Head, Turn Head
 - DTI Under Nut, Turn Head

*Note: Special washers may be required for larger bolts.





Step 6: Check Values

Table 2. Minimum Installation Tension Required for the Pre-installation Test

Bolt Dia.	3/4"	7/8"	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"
A325 Kips	29 Kips	41 Kips	54 Kips	59 Kips	75 Kips	89 Kips	108 Kips

Type 9/10 Structures

Type 12/13 Structures

Table 4. Maximum Allowable Torque (Tension is measured in Kips or 1,000s of pounds and torque is measured in ft.-lbs.)

3/4" Diameter		7/8" Diameter		1" Diameter		1 1/8" Diameter		1 1/4" Diameter		1 3/8" Diameter		1 1/2" Diameter	
Kips Tension	Max. Torque	Kips Tension	Max. Torque	Kips Tension	Max. Torque	Kips Tension	Max. Torque	Kips Tension	Max. Torque	Kips Tension	Max. Torque	Kips Tension	Max. Torque
29	453	41	748	54	1121	59	1387	75	1950	89	2559	108	3375
30	469	42	767	55	1141	60	1410	76	1976	90	2588	109	3406
31	484	43	785	56	1162	61	1434	77	2002	91	2616	110	3438
32	500	44	803	57	1183	62	1457	78	2028	92	2645	111	3469
33	516	45	821	58	1204	63	1481	79	2054	93	2674	112	3500
34	531	46	840	59	1224	64	1504	80	2080	94	2703	113	3531
35	547	47	858	60	1245	65	1528	81	2106	95	2731	114	3563
36	563	48	876	61	1266	66	1551	82	2132	96	2760	115	3594
37	578	49	894	62	1287	67	1575	83	2158	97	2789	116	3625
38	594	50	913	63	1307	68	1598	84	2184	98	2818	117	3656
39	609	51	931	64	1328	69	1622	85	2210	99	2846	118	3688
40	625	52	949	65	1349	70	1645	86	2236	100	2875	119	3719
41	641	53	967	66	1370	71	1669	87	2262	101	2904	120	3750
42	656	54	986	67	1390	72	1692	88	2288	102	2933	121	3781
43	672	55	1004	68	1411	73	1716	89	2314	103	2961	122	3813
44	688	56	1022	69	1432	74	1739	90	2340	104	2990	123	3844

Use PD/4 for other value not on this form. Where P=Tension in Kips, D=diameter of bolts in feet (divide by 12 to obtain feet).





DT 2322

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 - DTI Under Nut, Turn Nut
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*Note: Special washers may be required for larger bolts.





Signatures

Torque Wrench – Make, Model and Serial Number (prior to Calibration Date) [Redacted]		
Torque Wrench Calibration Date (m/d/yyyy) (<i>Calibration Date MUST be Within 1 Year</i>) [Redacted]		Structure ID Number [Redacted]
Contractor Name [Redacted]		
Date (m/d/yyyy) [Redacted]	Contractors Representative (QC) Name [Redacted]	Contractors Representative (QC) Signature X
Date (m/d/yyyy) [Redacted]	Wisconsin Department of Transportation Representative (QA) Name [Redacted]	WisDOT Representative (QA) Signature X

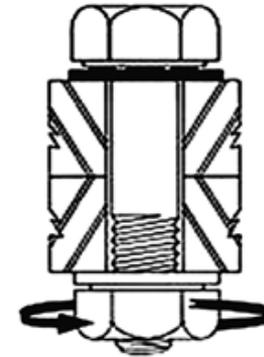


Installation & QC

INSTALLATION

Once the pre-installation test has been performed the following steps should be performed for installation:

- Lubricate each nut (face and threads) with wax based lubricant just prior to installation.
- Install bolts with the same configuration as tested in the Preinstallation Test Step 8. Install with the number of hardened washers as specified in the shop drawings.
- Snug connection from tightest point to edge until the plies are in *firm contact* at each bolt.
- Once all the bolts are snugged – tension the bolts until each DTI reaches *one refusal more than* the average of three in Table 3.



*DTI under head,
turn nut to tighten,
bolt head held.*

*Preferred method,
shown for
informational
purposes only.*

QUALITY CONTROL

The contractors QC should check the following items for *each connection of each structure*.

- Check that bolts, nuts, and washers are the correct grade and type, along with documentation of the Ro-Cap test performed by the supplier – See Step 2 (page 1).
- Check that washers for bolts over 1 1/8" conform to DTI manufacturer's recommendations and shall only be 1/16" diameter larger ID than the bolt diameter.
- Check that hardened washers are used on plies that have oversized bolt holes (when necessary) and match the number of hardened washers specified in the shop drawings.
- Check the configuration of the bolt assemblies is the same as the preinstallation – Test Step 8.
- Check the plies to be in firm contact at each bolt prior to tensioning.
- Check that DTI's are compressed to one more refusal than the average found in Table 3.
- Check any shop installed A325 bolts that have been tensioned or reinstalled in the field.



Why do we do all this?





Above Ground Checklist



Construction and Materials Manual

Wisconsin Department of Transportation

Chapter 6 Miscellaneous Construction

Section 55 Electrical Construction

Figure 3 Traffic Signal Installation Checklist

1. GENERAL

- a. Are all materials delivered to the job site in accordance with the specifications

2. CONDUIT AND CABLE

- a. Is any conduit used underground of a thin wall type? If so, it is unacceptable. Only PVC of Schedule 40 or heavier, or rigid metallic conduit is acceptable for underground use.
- b. Is the specified underground multi-conductor cable used?
- c. Is the traffic signal cable routed per plan?
- d. Is a loop of approximately 24" of multi-conductor cable left in the base of signal columns for splice purposes?
- e. Is an unused wire in the underground cable stripped back to be used for the equipment grounding conductor?
- f. Are bushings used on all rigid metallic conduit and end bells on non-metallic conduit?
- g. Are all pipe and bolt threads coated with a heavy coating of an approved rust-prohibitor, anti-corrosion, anti-seize compound?

3. BASES AND PEDESTALS

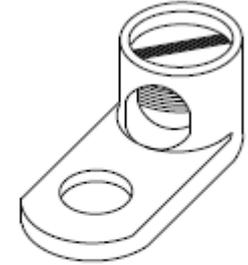
- a. Are all concrete bases of a proper depth?
- b. Are pole caps installed to keep water and snow out of the poles and standards?
- c. Is the signal pedestal leveled on the concrete base?





Bases & Pedestals

- Are they level?
- Bonding lug present?
- Bonding wire installed?
- Where is the access door relative to traffic?
- Anti-Seize used?
- Shims used? Less than 4?



**TYPICAL MECHANICAL
CONNECTOR LUG**
TO BE FURNISHED WITH EACH BASE





Poles & Arms

- Proper pole type/arm installed?
- Is pole plumb/level?
- What is orientation of the hand hole in relation to traffic?
- Has the pole cap been installed?
- Are the arms aligned properly?
- Grommet installed?
- Proper connection hardware?





Signal Heads

- Is lens configuration in accordance with MUTCD?
- Are overhead signals aimed properly? (pointing down the proper lane, level, plumb, etc.)
- Has the proper clearance been provided under vehicle or pedestrian heads?
- Are the overhead signals too high?
- Were heads properly secured to standard or arm?
- Correct PDM hardware?
- Heads covered?





Cabinets

- Is cabinet oriented properly with the roadway?
- Are end bells present?
- Have the cables leading into the cabinet base been labelled?
- Has debris/metal shavings been cleaned out from the bottom of the cabinet?
- Has cabinet been properly anchored?

