WEST VIRGINIA DEPARTMENT OF TRANSPORTATION

DIVISION OF HIGHWAYS

MATERIALS CONTROL, SOILS & TESTING DIVISION

MATERIALS PROCEDURE

ANCILLARY STRUCTURE ANCHOR BOLT TIGHTENING

1. PURPOSE

1.1 To establish equipment, procedure, documentation, and documentation transmittal requirements for the tightening of anchor bolt nuts associated with signing, signal, lighting, and intelligent transportation systems (ITS) related roadway ancillary structures.

1.1.1 This Materials Procedure is specifically focused on the procedure to be followed when tightening anchor bolt nuts and does not address all requirements and procedures pertaining to the installation of ancillary structures. Individual component pre-inspection and repair, structure pre-assembly, structure installation preparation, pre-application of protective coatings, overall installation procedure, and proper tightening of structural connection bolts are included as part of the Standard Specifications.

2. MATERIALS AND EQUIPMENT

2.1 The mandatory materials and equipment required to properly tighten the anchor bolts include lubricant, and a hydraulic fastener tightening wrench.

2.1.1 Beeswax or toilet ring wax may be used as lubricant.

2.1.2 Hydraulic wrenches and accompanying documentation are to meet the requirements herein.

2.1.2.1 The wrenches are to be capable of generating the necessary torque in order to tighten the anchor bolt nuts as described herein.

2.1.2.2 The hydraulic wrench consists of a wrench and a hydraulic power pack to power and operate the wrench.

2.1.2.3 Hydraulic wrenches are to have the wrench and the pressure or torque readout gauge associated with the power pack calibrated regularly. Prior to the tightening of any anchor bolt nuts, the project Engineer is to be provided with separate calibration certificates for the wrench and the gauge. The dates of the calibrations are to be one year or less prior to the date that the bolt tightening is performed. The certificates are to be from a calibration lab that is International Organization for Standardization (ISO) 17025 accredited, with the certificate indicating as such. The certificate for

each is to display a serial number matching that shown on the wrench or gauge. If the gauge does not provide readings directly in torque values, the calibration certificate is to be accompanied by calibration charts which equate gauge pressure readings to torque values. Example calibration certificates and charts are included as part of ATTACHMENT 1.

3. DOCUMENTATION

3.1 The tightening of all anchor bolt nuts is to be documented using the form "WVDOH ANCILLARY STRUCTURE ANCHOR BOLT TIGHTENING RECORD" (documentation form) attached as ATTACHMENT 2, and available at the MCS&T DOH Webpage.[1]

4. PROCEDURES

4.1 Install the top nuts and washers and verify that the top nuts & washers, as well as the leveling nuts & washers, are all in firm contact with the base plate. Snug tighten the top nuts and leveling nuts utilizing the hydraulic wrench and the following procedure:

4.1.1 Use a permanent marker to indicate on the base plate the sequence of tightening to be followed. The sequence shall be a star pattern, examples of which are provided in Figures 1 and 2 below.

4.1.2 Snug tighten the top nuts to approximately 50% of the snug tightened condition torque values specified in Table 1 below following the star pattern.

4.1.3 Snug tighten the bottom nuts to approximately 50% of the snug tightened condition torque values specified in Table 1 below following the star pattern.

4.1.4 Snug tighten the top nuts to 100% of the snug tightened condition torque values specified in Table 1 below following the star pattern.

4.1.5 Snug tighten the bottom nuts to 100% of the snug tightened condition torque values specified in Table 1 below following the star pattern.

[1] https://transportation.wv.gov/highways/mcst/Pages/tbox.aspx

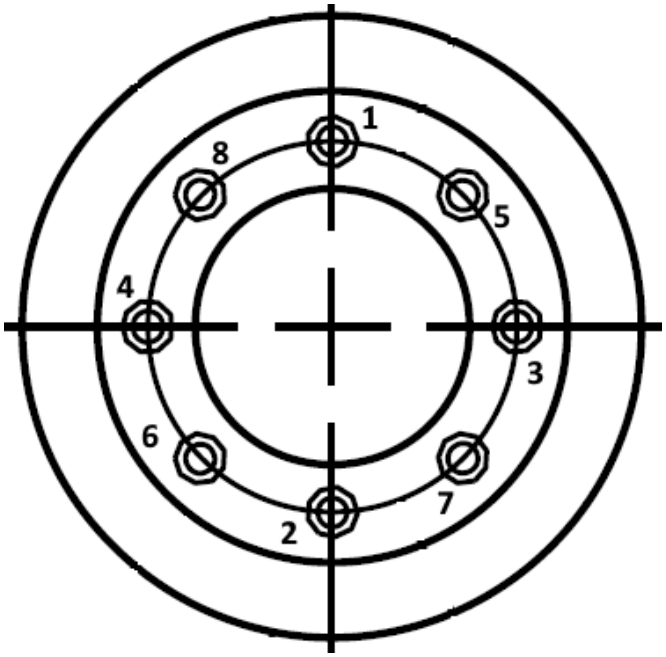


Figure 1 - Example Nut Tightening Sequence For 8 Bolt Base Plate

Figure 2 -Snug Tightening Sequence Numbering On Base Plate

Diameter (in.)	Threads/inch	Snug Torque Value (ft-lbf)
1-1/4 (32 mm)	7 (3.629 Pitch in mm)	140 (190 Nm)

1-1/2 (38 mm)	6 (4.233 Pitch in mm)	240 (325 Nm)
1-3/4 (44 mm)	5 (5.080 Pitch in mm)	380 (515 Nm)
2 (51 mm)	4.5 (5.664 Pitch in mm)	570 (775 Nm)
2-1/4 (57 mm)	4.5 (5.664 Pitch in mm)	830 (1125 Nm)

Table 1 – Snug Tightened Torque Values For Astm F1554 Grade 55 Anchors (Contact Traffic Engineering Division For Anchors Outside Those Covered By This Table)

4.2 After all nuts have been snug tightened and the necessity or unnecessity for repeating the snug tightening procedure with beveled washers has been determined and performed if required, snug tight condition reference marks are to be placed on the nut and base plate using a permanent marker to prepare for the full tightening procedure(see Figure 3 below). One reference mark is to be placed on the top of the nut at one of the corners. One reference mark is to be placed on the base plate such that this reference mark and the reference mark on top of the nut will be aligned when the nut is rotated one half of the amount specified in Section 4.3.1. An additional reference mark is to be placed on the base plate such that this reference mark and the reference mark on top of the nut will be aligned when the nut is rotated the complete amount specified in Section 4.3.1. All reference marks are to be placed such that they will remain visible when the tightening wrench is placed on the nut.

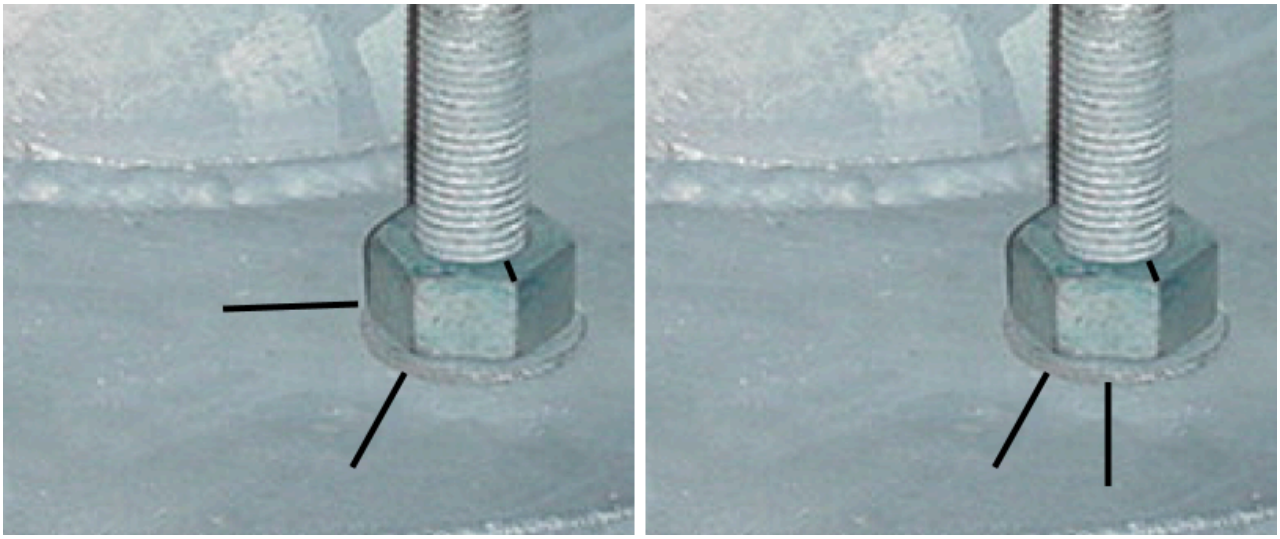


Figure 3 - Snug Tight Condition Reference Marks For Bolts 1-1/2” Diameter Or Less (Left) And Bolts Greater Than 1-1/2” Diameter (Right)

4.3 Fully tighten the top nuts using the hydraulic wrench.

4.3.1 Full tightness of each nut is achieved by rotating the nut a prescribed number of flats beyond the reference position. Rotation is to be 1/3 (2 flats) beyond the reference position for bolts 1-1/2-inches in diameter or less. Rotation is to be 1/6 (1 flat) beyond the reference position for bolts greater than-1-1/2 inches in diameter.

4.3.2 Tightening is to proceed from nut to nut in the same star pattern that was used for the snug tightening procedure and is to be achieved over two cycles. Using a structure with 2-inch anchor bolts as an example, each nut is to be tightened ½ flat. Each nut is to then be tightened an additional ½ flat.

4.4 Upon completion of the tightening of all nuts, a verification torque (Tv) is to be applied to each nut using the same hydraulic wrench and power pack that was used to tighten the nuts. The required verification torque is to be based on Table 2 below. The applied torque is not to exceed this value.

Diameter (in.)	Threads/inch	Tv Value (ft-lbf)
1-1/4 (32 mm)	7 (3.6 Pitch in mm)	550 (745 Nm)
1-1/2 (38 mm)	6 (4.2 Pitch in mm)	950 (1290 Nm)
1-3/4 (44 mm)	5 (5.1 Pitch in mm)	1500 (2035 Nm)
2 (51 mm)	4.5 (5.7 Pitch in mm)	2250 (3050 Nm)
2-1/4 (57 mm)	4.5 (5.7 Pitch in mm)	3290 (4460 Nm)

Table 2 – Verification Torque Values For Astm F1554 Grade 55 Anchors (Contact Traffic Engineering Division For Anchors Outside Those Covered By This Table)

If the gauge associated with the power pack does not provide a torque readout, the pressure readout required to achieve the verification torque is to be determined from the power pack calibration charts.

4.4.1 The documentation form is to be marked where indicated to indicate that a torque value of at least that provided in Table 2 would be required to further tighten the nuts. If the nuts further tighten prior to achieving the verification torque, the Traffic Engineering Division is to be notified of this issue.

4.5 At least 48-hours after the tightening and verification torque procedures are completed, and after all attachments (signs, lighting, etc.) have been installed on the structure, a torque equal to 110% of the Tv torque is to be applied to each nut using the same hydraulic wrench and power pack that was used to tighten the nuts. The 110% Tv torque is to be based on Table 3 below. The applied torque is not to exceed this value.

Diameter (in.)	Threads/inch	110% Tv Value (ft-lbf)
1-1/4 (32 mm)	7 (3.6 Pitch in mm)	605 (880 Nm)
1-1/2 (38 mm)	6 (4.2 Pitch in mm)	1045 (1410 Nm)
1-3/4 (44 mm)	5 (5.1 Pitch in mm)	1650 (2235 Nm)

2 (51 mm)	4.5 (5.7 Pitch in mm)	2475 (3355 Nm)
2-1/4 (57 mm)	4.5 (5.7 Pitch in mm)	3619 (4905 Nm)

Table 3 – 110% Verification Torque Values For Astm F1554 Grade 55 Anchors (Contact Traffic Engineering Division For Anchors Outside Those Covered By This Table)

If the gauge associated with the power pack does not provide a torque readout, the pressure readout required to achieve a torque of 110% Tv is to be determined from the power pack calibration charts.

4.5.1 The documentation form is to be marked where indicated to indicate that a torque value of at least that provided in Table 3 would be required to further tighten the nuts. If the nuts further tighten prior to achieving the 110% Tv torque, the Traffic Engineering Division is to be notified of this issue.

5. DOCUMENTATION TRANSMITTAL

5.1 Upon completion of all procedures described herein and the documentation form being completed in its entirety, the Engineer is to transmit an electronic copy of the documentation form to the email address DOH.OS.AnchorNutTightening@wv.gov, which is established by the Traffic Engineering Division for this purpose. Prior to transmittal, the calibration certificates for the wrench and power pack pressure or torque readout gauge, as well as the calibration charts for the gauge, should be attached to the documentation form and included with the submittal. The subject line of the email should be named using the following format: D(*District Number*)-(*Contract ID Number*)-(*Sign, Signal, Lighting, or ITS*) Structure (*Structure Number as indicated on the project Plans*). Examples of this would be D4-2016000994-Sign Structure 6 and D7-2006001093-Lighting Structure HML1. An example of all documents that should be included as part of a complete transmittal is attached as ATTACHMENT 1.

Michael Mance Digitally signed by Michael Mance
Date: 2024.08.01 14:03:18 -04'00'

Michael A. Mance, P.E.
Interim Director
Materials Control, Soils & Testing Division

MP 658.05.06 Steward – Traffic Certification Section
MM:W
ATTACHMENTS

EXAMPLE WRENCH CALIBRATION CERTIFICATE

CERTIFICATE INDICATES LAB IS ISO 17025 ACCREDITED

CERTIFICATE OF CALIBRATION

CERTIFICATE # TW-01193

[redacted] certifies that the instrument below has been calibrated in accordance with [redacted] calibration procedures under the conditions noted below using laboratory standards which are traceable to SI units.

The uncertainty represents an expanded uncertainty at approximately the 95% confidence level using a coverage factor of k=2

The information on this certificate applies only to the identified instrument and may not be reproduced, except in full, without the written consent of [redacted]

WRENCH MODEL AND SERIAL NUMBER

MODEL	2503MFRMH
SERIAL #	0916506063
TYPE	Click
CAL DATE	9/2/2021
CAL DUE	9/2/2022
ACCURACY	(+/-) 4%
RANGE MAX	260
RANGE MIN	48

CALIBRATION DATE

Customer	[redacted]
Address	[redacted]

Tech:	Temp (°F)	RH %
[redacted]	75.2	52
Test Method:	TI-CAL-1	

AS FOUND

PERCENT OF RANGE	WRENCH SETTING	AS FOUND	TOLERANCE
100%	250 FTLB	251.56 FTLB	(+/-) 4%
60%	150 FTLB	147.14 FTLB	(+/-) 4%
20%	50 FTLB	47.596 FTLB	(+/-) 4%

AS LEFT

PERCENT OF RANGE	WRENCH SETTING	AS LEFT	TOLERANCE
100%	250 FTLB	248.38 FTLB	(+/-) 4%
60%	150 FTLB	147.98 FTLB	(+/-) 4%
20%	50 FTLB	48.285 FTLB	(+/-) 4%

STANDARDS USED FOR CALIBRATION

MODEL USED	MFGR	SERIAL #	CERT #	EXPIRES	RANGE
MTMDP-4L-100	AWS	10963-1	25500-1	7/23/2022	10-100 IN-LBS
MTMDP-4L-500	AWS	10963-2	25501-1	7/21/2022	50-500 IN-LBS
MTMDP-4L-250	AWS	10963-3	25502-1	7/23/2022	25-250 FT-LBS
MTMDP-4L-750	AWS	10963-4	25503-1	7/23/2022	75-750 FT-LBS

Expanded Uncertainty	
Range	k=2
10-100 inlb	1.08 inlb
50-500 inlb	4.98 inlb
25-250 ftlb	7.44 ftlb
75-750 ftlb	8.86 ftlb

[redacted] 9/2/2021

SIGNATURE DATE

Revision: 3 Revised: 09/17/2019 Page 1 of 1 Form Number: CERT-9

EXAMPLE GAUGE CALIBRATION CERTIFICATE AND CHARTS

CERTIFICATE INDICATES LAB IS ISO 17025 ACCREDITED

Certificate of Calibration

CERTIFICATE # 14-03066

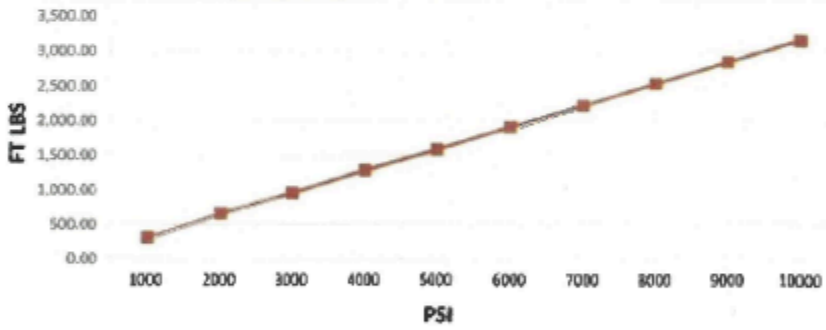
Calibration Date:	August 18, 2021
Calibration Due:	February 18, 2022
Temperature (F):	74.3
Relative Humidity(%):	57
Test Method:	TI-CAL-7, TI-CAL-8

Model Number:	3MD
Serial Number:	353228
Type:	Hydraulic
Technician:	[redacted]
Signature:	

Customer:	[redacted]
Address:	[redacted]

GAUGE MODEL AND SERIAL NUMBER

CALIBRATION DATE



TEST EQUIPMENT

Manufacturer	AKO	AKO
Model Number	TSD20011	TSD10KPT
Serial Number	6240	127064
Accuracy (+/-)	0.5%	0.1%
Calibration Certificate #	21238-1	21239-1
Calibration Due Date	10/15/2021	10/15/2021

Page 1 of 2

Revision: 3 Revised: 09/17/2019 Form Number: CERT-1

CALIBRATION CHART

ANAB ACCREDITED
CALIBRATION LABORATORY

Calibration Date:	8/18/2021	**Model Number:**	3MD
Calibration Due:	2/18/2022	**Serial Number:**	353228

PSI	FT/LBS	PSI	FT/LBS	PSI	FT/LBS	PSI	FT/LBS	PSI	FT/LBS
100	2	2100	692	4100	1307	6100	1940	8100	2573
200	52	2200	721	4200	1337	6200	1971	8200	2605
300	93	2300	752	4300	1368	6300	2003	8300	2637
400	125	2400	776	4400	1401	6400	2035	8400	2669
500	163	2500	797	4500	1434	6500	2067	8500	2702
600	195	2600	836	4600	1465	6600	2098	8600	2732
700	228	2700	880	4700	1496	6700	2131	8700	2764
800	259	2800	903	4800	1527	6800	2163	8800	2797
900	287	2900	924	4900	1560	6900	2194	8900	2828
1000	306	3000	956	5000	1591	7000	2225	9000	2860
1100	351	3100	987	5100	1622	7100	2257	9100	2891
1200	397	3200	1017	5200	1654	7200	2289	9200	2923
1300	426	3300	1048	5300	1685	7300	2321	9300	2954
1400	458	3400	1081	5400	1717	7400	2353	9400	2986
1500	491	3500	1113	5500	1749	7500	2384	9500	3018
1600	524	3600	1145	5600	1780	7600	2416	9600	3049
1700	556	3700	1177	5700	1812	7700	2447	9700	3081
1800	589	3800	1222	5800	1844	7800	2479	9800	3112
1900	623	3900	1267	5900	1876	7900	2511	9900	3143
2000	659	4000	1288	6000	1908	8000	2542	10000	3177

Tv = 2250 ft-lbs =7,078 psi*

1.10Tv = 2475 ft-lbs = 7787 psi*

Snug=570 ft-lbs=1742 psi*

[redacted] certifies that the above instrument has been calibrated in accordance with [redacted] calibration procedures under the conditions noted above using laboratory standards which are traceable to SI units. The uncertainty represents an expanded uncertainty at approximately the 95% confidence level using a coverage factor of k=2.

*DETERMINED USING LINEAR INTERPOLATION BETWEEN ADJACENT DATA POINTS

Expanded Uncertainty

Range	k = 2	Units
0-20,000	78.52	FT/LBS

WVDOH ANCILLARY STRUCTURE ANCHOR BOLT TIGHTENING RECORD

District: _____ State Project Number:_____

Contract ID number: _____ Federal Project Number:_____

Plan Assembly Number:_____

Structure Utility: __ Signing __Signal __Lighting __ITS

Structure Type: __ Cantilever __(Sign) Butterfly __(ITS) Butterfly __Span __Strain Pole
__Mast Arm __High Mast Tower __Conventional Light Pole

Anchor Diameter:_____inches Snug Tight Torque: _____foot-lbs=_____PSI

Tv: _____foot-lbs = _____ PSI

1.10Tv:_____foot-lbs = _____ PSI

Wrench Serial Number: _____ Gauge Serial Number:_____

Diagram of Structure (Plan view of structure showing all base plates. Show and label diagram with base plate numbers and location/position of structure in relation to a reference feature)

Base Plate 1 Diagram (Plan view of base plate with anchor bolt locations. Number anchor bolts the same as the anchors are numbered and tightened. Label diagram to indicate orientation of base plate in relation to a reference feature)

Mark Each Box to Indicate Nuts were Numbered and Top and Bottom Nuts were Snug Tightened

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Nut and Base Plate Indicator Lines were Placed and each Top Nut was Rotated the Number of Required Turns

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least Tv

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least 1.10Tv

1	2	3	4	5	6	7	8

Base Plate 2 Diagram

Mark Each Box to Indicate Nuts were Numbered and Top and Bottom Nuts were Snug Tightened

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Nut and Base Plate Indicator Lines were Placed and each Top Nut was Rotated the Number of Required Turns

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least Tv

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least 1.10Tv

1	2	3	4	5	6	7	8

Base Plate 3 Diagram

Mark Each Box to Indicate Nuts were Numbered and Top and Bottom Nuts were Snug Tightened

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Nut and Base Plate Indicator Lines were Placed and each Top Nut was Rotated the Number of Required Turns

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least Tv

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least 1.10Tv

1	2	3	4	5	6	7	8

Base Plate 4 Diagram

Mark Each Box to Indicate Nuts were Numbered and Top and Bottom Nuts were Snug Tightened

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Nut and Base Plate Indicator Lines were Placed and each Top Nut was Rotated the Number of Required Turns

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least Tv

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least 1.10Tv

1	2	3	4	5	6	7	8

Date of Tightening	Date of Application of 1.10Tv
Installation Contractor	Bolt Tightening WVDOH Rep. (Print)
Contractor Rep. (Print)	Application of 1.10Tv WVDOH Rep. (Print)
Contractor Rep. (Signature)	WVDOH Project Engineer (Print)

WVDOH ANCILLARY STRUCTURE ANCHOR BOLT TIGHTENING RECORD

District: _____ State Project Number:_____

Contract ID number: _____ Federal Project Number:_____

Plan Assembly Number:_____

Structure Utility: X Signing __Signal __Lighting __ITS

Structure Type: __ Cantilever __(Sign) Butterfly __(ITS) Butterfly X Span __Strain Pole
__Mast Arm __High Mast Tower __Conventional Light Pole

Anchor Diameter: 2 inches

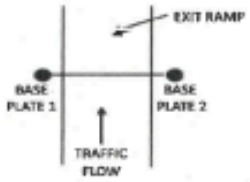
Snug Tight Torque: 570 foot-lbs= 1742 PSI

Tv: 2250 foot-lbs = 7078 PSI

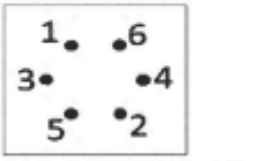
1.10Tv: 2475 foot-lbs = 7787 PSI

Wrench Serial Number: 0916506063 Gauge Serial Number: 353228

Diagram of Structure (Plan view of structure showing all base plates. Show and label diagram with base plate numbers and location/position of structure in relation to a reference feature)



Base Plate 1 Diagram (Plan view of base plate with anchor bolt locations. Number anchor bolts the same as the anchors are numbered and tightened. Label diagram to indicate orientation of base plate in relation to a reference feature)



Mark Each Box to Indicate Nuts were Numbered and Top and Bottom Nuts were Snug Tightened

1	2	3	4	5	6	7	8
X	X	X	X	X	X	X	X

Mark Each Box to Indicate Nut and Base Plate Indicator Lines were Placed and each Top Nut was Rotated the Number of Required Turns

1	2	3	4	5	6	7	8
X	X	X	X	X	X	X	X

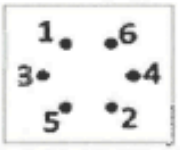
Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least Tv

1	2	3	4	5	6	7	8
X	X	X	X	X	X	X	X

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least 1.10Tv

1	2	3	4	5	6	7	8
X	X	X	X	X	X	X	X

Base Plate 2 Diagram



←RAMP TRAFFIC

Mark Each Box to Indicate Nuts were Numbered and Top and Bottom Nuts were Snug Tightened

1	2	3	4	5	6	7	8
x	x	x	x	x	x	x	x

Mark Each Box to Indicate Nut and Base Plate Indicator Lines were Placed and each Top Nut was Rotated the Number of Required Turns

1	2	3	4	5	6	7	8
x	x	x	x	x	x	x	x

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least Tv

1	2	3	4	5	6	7	8
x	x	x	x	x	x	x	x

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least 1.10Tv

1	2	3	4	5	6	7	8
x	x	x	x	x	x	x	x

Base Plate 3 Diagram

Mark Each Box to Indicate Nuts were Numbered and Top and Bottom Nuts were Snug Tightened

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Nut and Base Plate Indicator Lines were Placed and each Top Nut was Rotated the Number of Required Turns

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least Tv

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least 1.10Tv

1	2	3	4	5	6	7	8

Base Plate 4 Diagram

Mark Each Box to Indicate Nuts were Numbered and Top and Bottom Nuts were Snug Tightened

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Nut and Base Plate Indicator Lines were Placed and each Top Nut was Rotated the Number of Required Turns

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least Tv

1	2	3	4	5	6	7	8

Mark Each Box to Indicate Required Torque to Further Tighten each Top Nut would be at least 1.10Tv

1	2	3	4	5	6	7	8

Date of Tightening

Date of Application of 1.10Tv

Installation Contractor

Bolt Tightening WVDOH Rep. (Print)

Contractor Rep. (Print)

Application of 1.10Tv WVDOH Rep. (Print)

Contractor Rep. (Signature)

WVDOH Project Engineer (Print)