Technical Note 62

Assembly and Tensioning of High Strength Bolts and Nuts - Part 1: Class 8.8

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1 Clarification of bolt tensioning

The purpose of this technical note is to define the acceptable requirements for the assembly and tensioning of High Strength Bolts for Department of Transport and Main Roads (TMR) projects.

2 Reference documents

A number of reference documents have been used to compile this technical note. The reference documents are outlined below.

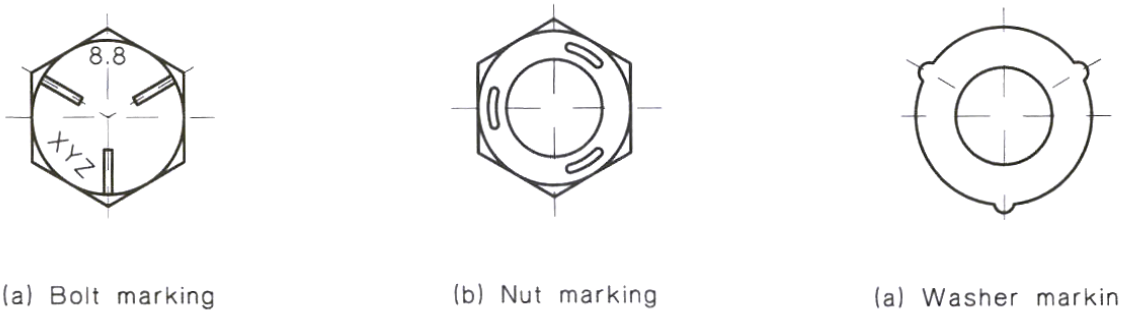
- Transport and Main Roads Technical Specification MRTS78 *Fabrication of Structural Steelwork*
- Australian Standard AS 4100 – 1998
- Australian Standard AS 1252 – 1996.

3 Identification of conforming materials

All bolts and nuts shall be from tested batches. All bolts and nuts shall be tested in accordance with MRTS78 *Fabrication of Structural Steelwork*.

The contractor shall only use bolts, nuts and washers complying with AS 1252. These bolts, nuts and washers have identification marks embossed on the top of the bolt head, the top surface of the nut and protrusions on the edges of the washers. Figure 3 shows the markings for the bolt, nut and washer.

Figure 3 – Markings for structural assemblies



Inspection by the contractor of bolts, nuts and washers for damage to the threads and the galvanising shall take place before fitting. The contractor shall discard any damaged bolts, nuts and washers.

4 Tensioning of bolts

There are three bolting categories defined in AS 4100-1998.

4.1 8.8/S

The bolts are installed and tensioned to “snug tight”. AS 4100 defines snug tight as, "The tightness attained by a few impacts of an impact wrench or by the full effort of a person using a standard podger spanner”, which brings the connecting parts into firm contact.

4.2 8.8/TF and 8.8/TB (or 8.8/T when referring to both types)

The bolts are installed and are fully tensioned in a controlled manner.

There are four methods of tensioning the bolts:

1. **The use of an adjustable and correctly calibrated impact wrench**. The equipment required is a load cell (similar to the Skidmore Willhelm Gauge) and an adjustable impact wrench. This equipment is unavailable. Therefore, the contractor will be unable to use this method.
2. **The use of the part turn method**. Please note this method is not permitted as, there is a variation in bolt tension using this approach.
3. **The use of load indicator washers**. This method would be acceptable, for when the bolt head and load indicator washer can be clearly seen.
4. **There is another method not in the Code**. Some bolts/rivets requiring replacement have their heads inside chord members. This would make checking the gap between the load indicating washer and the underside of the head difficult. By using an adjustable impact wrench, calibration of the system could occur by assembling a series of bolts, nuts and load indicating washers in a simple joint in the workshop. Calibration of the wrench would be by using load indicator washers to determine the appropriate wrench setting for field usage.

5 Non acceptable method of tensioning bolts

The reason the part turn method is not acceptable is outlined below.

A typical structural bolt, for example a M24 bolt will typically require a torque of approximately 800 Nm in order to fully tension the bolt. A torque of 800 Nm is equivalent to applying a force of 81kg over a 1000 mm long spanner. The normal podge spanner is roughly 500 mm long, so assuming that the force could only be applied at about 400 mm, you would need to apply a force of 204kg at this distance.

In the past workers would place extensions on standard spanners in order to tension bolts, refer to Figure 5. This process is both risky from a safety perspective and does not ensure a consistent tension force is applied to all the bolts.

It is not practical to apply forces of this magnitude to a spanner particularly when working at heights. Hence why manual tensioning of bolts is not permitted.

Figure 5 – Extension placed on the end of a ring spanner

6 Acceptable method for tensioning bolts

The accepted method for fully tensioning T/F and T/B bolts is as follows.

6.1 Load indicating washers

When the bolt head and nut are clearly visible at a bolted connection, the load indicating washers shall be used. There are two types of load indicating washers.

Conventional load indicating washer - The first type of load indicating washer is the conventional load indicating washer as outlined in AS/NZS 1252. After tensioning, the average gap needs to be measured with a feeler gauge. For galvanised bolts, the minimum gap required between the head and the load indicating washer is 0.25 mm.

Squirter DTI load indicating washers - The second type of load indicating washer is the “Squirter DTI” supplied by Hobson Engineering. As the bolt is tensioned, a calibrated amount of orange silicone appears from under the DTI’s squirt locations.

If the Squirter DTI load indicating washers are used. The bolting arrangement will need to be calibrated for each batch of load indicating washers supplied for the project.

6.1.1 Squirter DTI calibration of load indicating washers

In a Skidmore – Insert a bolt, Squirter DTI, washer and nut into the Skidmore. Tighten the assembly to about 10% to 20% over the minimum required tension as outlined in AS 4100, in the same manner to be used to tension the bolt assembly. Once tightened, note the appearance of the flow volume and the number of squirts emanating from under the DTI. If the DTI has five bumps there should be at least four squirts from the DTI. The calibration process will need to be repeated a total of three times to obtain a visual impression of how much squirt is necessary.

In Solid Steel – Insert a bolt, Squirter DTI, washer and nut into a steel section. Tighten the bolt assembly until the DTI has sufficiently compressed so that a feeler gauge of the correct thickness (0.13 mm (0.005") if the DTI is on the nut end, or 0.13 mm (0.005") if the DTI is under the head) will not enter half of the available places right into the bolt shank. If it does, tighten the bolt a little more and note the silicone squirt volume and appearance. The calibration process will need to be repeated a total of four times to obtain a visual impression of how much squirt is necessary.

Note: For installation of Squirter DTI’s in old or reconditioned steelwork, it may be necessary to place hardened flat washer against the steel surface and under the Squirter DTI’s so that the squirter feature works reliably.

7 Acceptable method for tensioning bolts

The accepted method for fully tensioning T/F and T/B bolts is as follows. For the tensioning of the Class 8.8 bolts, only a calibrated torque wrench can be used.

7.1 Types of tensioning equipment

Figure 7.1(a) – Electric torque wrench – Accuracy of +/- 4%

Figure 7.1(b) – Hydraulic torque wrench

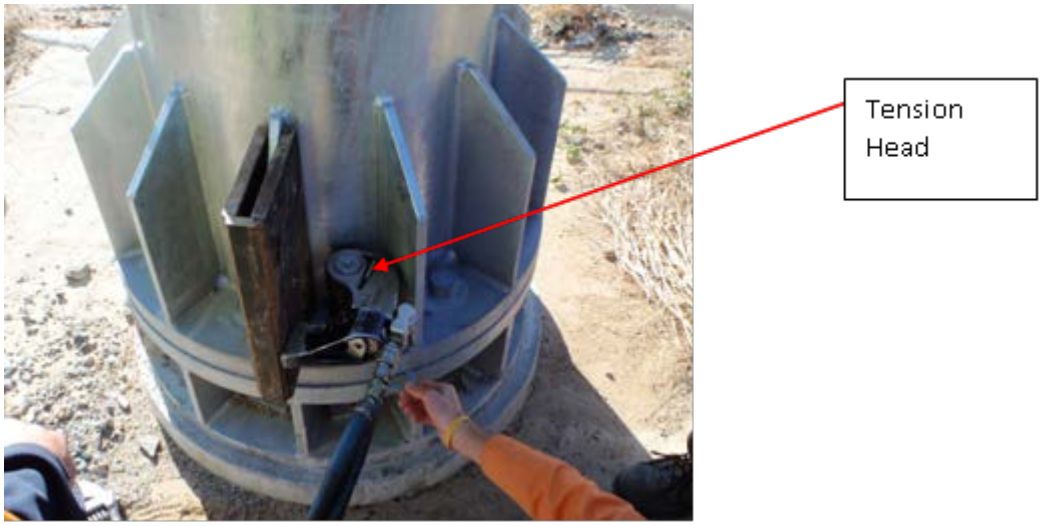
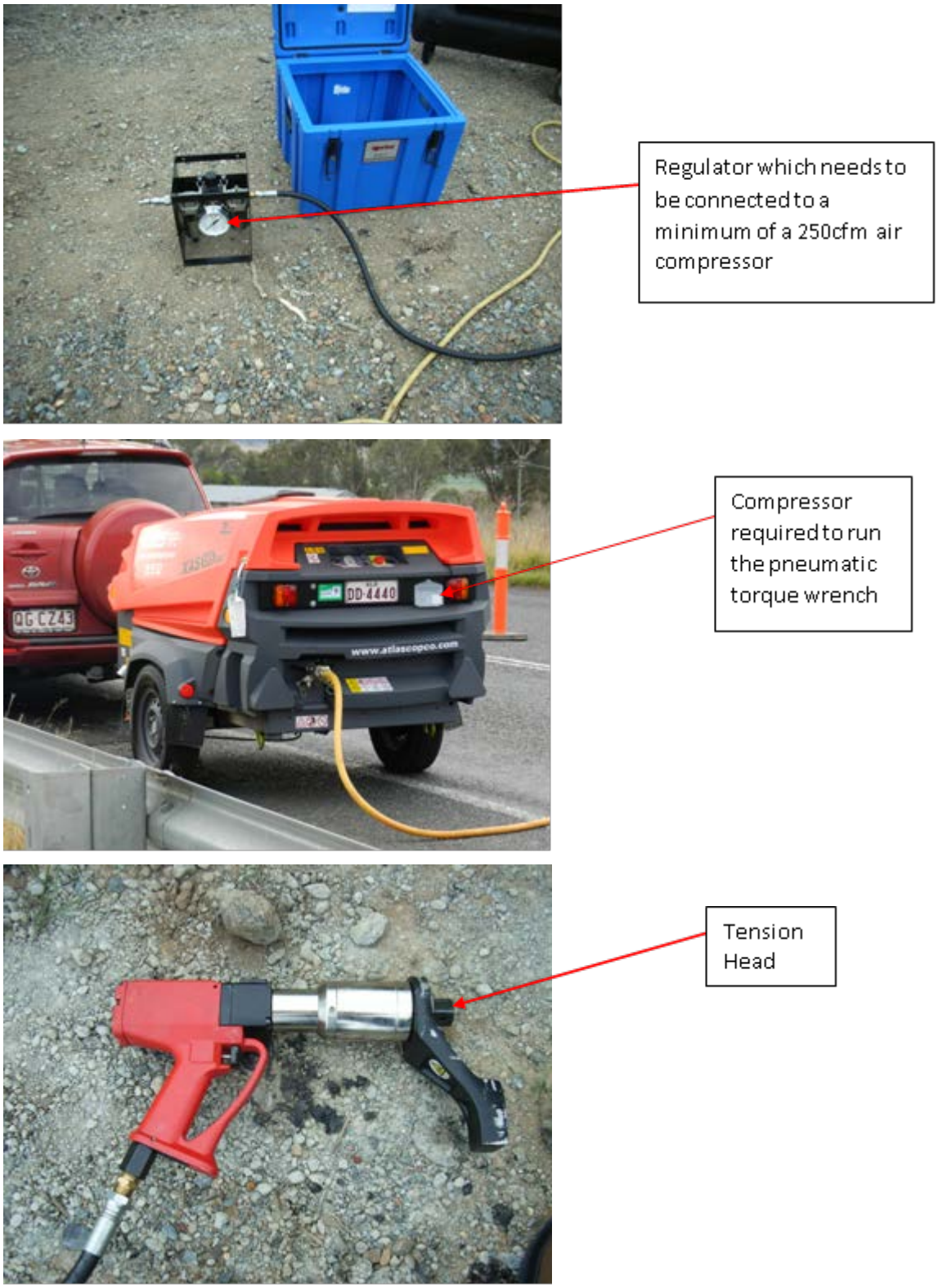


Figure 7.1(c) – Pneumatic torque wrench



7.2 Calibrated impact wrench

This process is only permitted when the bolts already in stock are too short to accommodate the washer, nut and load indicating washer. In order to ensure that the tension wrench is correctly calibrated, there are two options available.

Option 1

1. Place a bolt assembly in a Skidmore Willhelm Gauge with a Squirter DTI load indicating washer Refer to Figure 7.2(a)
2. Tension the bolt with a tension wrench to the required tension as outlined in AS 4100 and Table 7.2
3. Note the torque setting on the tension wrench to achieve the required tension force. Please note that the torque setting is based on the constant application of force in a single movement
4. Once the torque wrench has been set for the specific bolt and nut, the torque wrench is placed on a Norbar True Checker, refer to Figure 7.2(d). The True Checker will confirm the torque setting for that specific bolt and nut combination.

Figure 7.2(a) – View of a skidmore

Table 7.2 –Minimum bolt tension

Nominal diameter of bolt		Minimum Bolt Tension kN	Max Upper Limit Bolt Tension kN
M16		95	115
M20		145	185
M22		180 (Note 1)	230 (Note 1)
M24		210	265
M30		335	420
M36		490	610

Note 1: M22 tension capacity based on linear interpolation

Option 2

- Place a bolt, nut and washer assembly along with a Squirter DTI load indicating washer in a solid steel section Refer to Figure 7.2(b).
- Ensure that the load indicating washer is installed in the correct orientation as shown in Figure 7.2(c).
- Tension the bolt with a tension wrench until the DTI has sufficiently compressed so that a feeler gauge of the correct thickness (0.13 mm if the DTI is on the nut end, or 0.13 mm if the DTI is under the head) will not enter half of the available places right into the bolt shank. If it does, tighten the bolt a little more and note the silicone squirt volume and appearance. The calibration process will need to be repeated a total of three times to obtain a visual impression of how much squirt is necessary.
- Note the torque setting on the tension wrench to achieve the required tension force. Please note that the torque setting is based on the constant application of force in a single movement.
- Once the torque wrench has been set for the specific bolt and nut, the torque wrench is placed on a Norbar True Checker, refer to Figure 7.2(d). The True Checker will confirm the torque setting for that specific bolt and nut combination.

Figure 7.2(b) – Bolt placed in a tensioning plate

Figure 7.2(c) – Correct orientation for a load indicating washer

Figure 7.2(d) – View of the torque wrench on the True Checker

True Checker device is used to outline the torque setting for a torque wrench. Many wenches are set via pressure and the true checker determines the torque in the torque wrench for a specific pressure. True Checker can also be used to ensure the torque in the torque wrench correctly calibrated.

8 Installation of the bolts, nuts and washers

The nut must be able to run freely up and down the bolt. The correct way to clear a blockage is to run the nut up and down the thread until the nut is free running. If the nut still will not run freely on the bolt the contractor shall discard the nut and the bolt. This procedure must occur before taking bolts and nuts to site.

The contractor shall draw together the two surfaces which require joining so they are in full contact. This may involve the use of tacking bolts. Once the parts are in full contact, the contractor shall replace any tacking bolts with high strength bolts one at a time.

The following requirements are to be satisfied:

- Driving of high strength bolts into the holes is unacceptable. In order to fit the bolts without force, the contractor may ream or drift the holes.
- Washers are required under both the head of the bolt and the nut.
- Lubricate the bolt thread with “Stearin Wax” or “Relton Stick Wax” prior to installing the nut on the bolt.
- There shall be a minimum of one full thread projecting above the top of the nut after assembly.
- If one full thread is not visible, then a longer bolt shall be used. If selecting a longer bolt, the maximum amount of projection of the bolt end passed the nut shall be 15 mm. Packing with up to three washers not exceeding 12 mm thickness is acceptable on the joint side not being turned.
- Note: The reason a bolt cannot have to too much thread projection is due to the bolt not having sufficient thread and when tightened the nut can run out of thread and will not be tensioned correctly.
- Once all the bolts are assembled, the bolts shall be tensioned so they are snug tight and the connecting surfaces are drawn together.

8.1 Acceptance criteria for bolt tensioning – Load indicating washers

When load indicating washers are used to validate that the bolt is correctly tensioned, the following requirements must be followed.

A load indicating washer has locations available to place the feeler gauge in between the flat washer and load indicator washer. Refer to Figure 8.1(a) and Figure 8.1(b).

Figure 8.1(a) – How to check a loading indicating washer

Figure 8.1(b) – How to check a loading indicating washer

A bolt is correctly tensioned once a correct thickness feeler gauge cannot be inserted up to the shank of a bolt in half the available spaces. Table 8.1 outlines the acceptable criteria based on a load indicating washer which has five available spaces to insert a feeler gauge.

Table 8.1 – Bolt tensioning acceptability

Number of Available Places	Accept or Reject	Comment
5	Reject	Bolt is too loose. Keep tensioning
4	Reject	Bolt is too loose. Keep tensioning
3	Reject	Bolt is too loose. Keep tensioning
2	Accept	
1	Accept	
0	Reject	Bolt is too tight. Bolt shall be replaced with a new bolt

9 Check of Torque and Re-Calibration

Once all the initial calibration of the torque wrench for each bolt and nut combination and has been completed, it is important to ensure the torque wrench is operating at the correct settings.

9.1 Check of Torque Setting

During the course of a working shift the torque setting will need to be checked as per the requirement outlined in Table 9.2, “Check of Torque Setting”. To check the torque the torque wrench is placed on the True Checker and the torque wrench operated until it stops turning. The torque setting on the display should match the settings recorded for that specific bolt and nut. If the torque value when checked is slightly out, then torque wrench shall be adjusted so the correct torque is achieved.

Note: the tolerance on the torque setting shall not vary by more than +/- 10 Nm.

9.2 Re-Calibration

It is also important to ensure the torque wrench is correctly calibrated. The checking of the calibration is dependent on how often the bolts are being tightened on a project. Table 9.2, “Torque Check and Re-calibration Testing”, outlines the frequency at which the re-calibration should be performed.

To carry out the re-calibration Section 7.2 is followed using one bolt from the previously tested batch of bolts.

Table 9.2 – Torque Check and Re -Calibration Testing

Time between Last Bolt Assembly	Check of Torque Setting	Recalibration Requirement
Tension bolts on a daily basis	Start of Day Shift, 11am – 12pm and 2pm - 3pm or Start of Night Shift, 11pm – 12am and 2am – 3am	On a monthly basis
Tension bolts on a weekly basis	Start of Day Shift, 11am – 12pm and 2pm - 3pm or Start of Night Shift, 11pm – 12am and 2am – 3am	On a weekly basis
Tension bolts on a monthly basis or longer	Start of Day Shift, 11am – 12pm and 2pm - 3pm or Start of Night Shift, 11pm – 12am and 2am – 3am	Before undertaking work on a bolted joint

10 Marking of Tensioned Bolts

Once a bolt assembly has been tensioned, the bolt on the nut end shall be marked with a paint pen to signify the bolt has been tensioned, refer to Figure 10.

Figure 10 – View of the marking of the bolt