



Torque, Tension, Angle, and Compression Evaluation of Fastened Joints

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. To determine the dynamic torque, tension, angle, and compression characteristics of the threaded fastener joint with bushing inner sleeve as compressed member.

1.2 Applicability. Unless otherwise specified, this procedure applies to the initial tightening event of joints using new threaded fasteners, bearing surfaces and clamped members for each joint.

1.3 Remarks.

1.3.1 Limitations. This procedure does not apply to Pulse tools.

1.3.2 Unless otherwise specified, any requirements or direction provided in the Test Request documentation will supercede this test procedure.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW25

3 Resources

3.1 Facilities. GM approved laboratory or location for this test procedure.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 Torque angle transducer.

3.2.2 Data acquisition system capable of collecting data at a sampling rate of at least 1000 Hz, plotting data at user specified scales, and identifying data at all points on the curve.

3.2.3 Strain gaged fastener, force washer, or fastener prepared for ultrasonic measurement.

3.2.4 Ultrasonic measurement device (if required).

3.2.5 Strain gaged bushing inner sleeves.

3.2.6 Load frame.

3.2.7 Tightening tool.

3.2.8 Appropriate fixturing, adapters, bedplate, or slotted table.

3.2.9 Strain indicator.

3.3 Test Vehicle/Test Piece.

3.3.1 A complete bill of materials of required test pieces will be specified in the Test Request documentation.

3.3.2 Unless otherwise specified, a minimum of eight joints are to be used for this procedure plus a minimum of two additional bushing inner sleeves for bushing load deflection test.

3.4 Test Time.

Calendar time: 1 week to 2 weeks

Test time: 24 h

Coordination time: 8 h

3.5 Test Required Information. Test Request documentation should outline specific information and test parameters (similar to Appendix A, Data Sheet A1 example).

3.6 Personnel/Skills. Test Technician shall be qualified on the basis of appropriate education, training, experience and/or demonstrated skills.

4 Procedure

4.1 Preparation.

4.1.1 Bushing Load Deflection Test.

4.1.1.1 Fasteners, bushings, and associated components should be inspected for conformity to specification (including surface specification for ends of bushing, dimensional measurements on the sleeve and brackets, or a measurement of the gap between them) per applicable drawing(s) or as directed by the test requestor.

4.1.1.2 Install the adapters in the load frame. Install and hook up the instrumentation. The linear displacement measurement device should be mounted so that it measures between the adapters of the ram and the plate in as direct a manner as possible with its centerline as close to the ram centerline as the test parts will permit.

Fixturing deflection may be erroneously interpreted as test part deflection if care is not exercised in the setup.

4.1.1.3 Calibrate the instrumentation to record expected full scale values for force and deflection.

4.1.1.4 Run a force-deflection test up to maximum requested load with fixturing and adapters alone (no test parts). If desired to minimize load frame height readjustment, a solid steel block with parallel sides and height similar to bushing may be placed between the load frame adapters.

4.1.1.5 Start the recording device and begin loading the fixturing.

4.1.1.6 Continue increasing the force until the maximum requested load is achieved.

4.1.1.7 Decrease the load to 0 while still recording.

4.1.1.8 If requested, repeat 4.1.1.4 through 4.1.1.7.

4.1.1.9 Remove the inner sleeve from a bushing assembly by cutting away the surrounding metal and rubber. Do not damage bushing inner sleeve.

Inner sleeves may be available separately from bushings for prototype level parts.

4.1.1.10 Install the bushing inner sleeve test specimen into the load frame to load the sleeve axially.

4.1.1.11 Start the recording device and begin loading the bushing. Use displacement control at a rate of 0.1 mm/s.

4.1.1.12 Continue increasing the force until the maximum requested load is achieved.

Test shutoff parameters may include, but are not limited to:

4.1.1.12.1 One hundred ten percent (110%) of fastener proof load.

4.1.1.12.2 Onset of permanent bushing deformation.

4.1.1.12.3 Load capability of the load frame and/or load cell.

4.1.1.13 Decrease the load to 0 while still recording.

4.1.1.14 Optional: Repeat 4.1.1.10 through 4.1.1.13 using a complete bushing assembly (inner sleeve plus surrounding metal and rubber still intact).

4.1.1.15 Repeat 4.1.1.10 through 4.1.1.14 for the total number of samples requested.

4.1.1.16 Visually inspect the test parts and record if or how they were deformed.

4.1.1.17 Photograph the test setup and the test components after test.

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4.1.1.18 Review load vs. displacement plots with test requestor. Curve from sample with fixturing and adapters alone (no test parts) should be linear with minimal offset. Curves from bushing inner sleeve and complete bushing assembly samples should be linear up to desired calibration load, which is to be 110% of fastener proof load unless otherwise specified by test requestor.

4.1.2 Bushing Strain Gaging and Calibration.

4.1.2.1 Remove the remaining inner sleeves from the bushing assemblies by cutting away the surrounding metal and rubber. Do not damage bushing inner sleeve. Inner sleeves may be available separately from bushings for prototype level parts.

4.1.2.2 If there are teeth or serrations on the ends of the sleeves, then aluminum plates should be used between the loading device and sleeve ends.

4.1.2.3 Optional: Cycle inner sleeves at least five times up to the desired calibration load of the sleeve then back down to zero load on a load frame. To remove residual stresses in the sleeves (work hardening processes), operate at a slow ram rate.

4.1.2.4 Attach strain gages on the inner sleeves, full bridge wired for axial loading, and cycle at least five times.

4.1.2.5 Balance the strain gaged sleeve, compress to the desired calibration load, and return to zero load. Record calibration data five times for both increasing and decreasing load, from the load cell and strain gages and average the results.

4.1.2.6 Evaluate the data and repeat 4.1.2.5 if necessary.

4.1.2.7 Provide error graph, sensitivity, shunt calibration load value, shunt calibration resistance value and/or resistor, and any other calibration data necessary to be compatible with the type of data acquisition system being used on test.

4.1.2.8 Repeat 4.1.2.1 through 4.1.2.7 for the total number of samples requested.

4.2 Conditions.

4.2.1 Environmental Conditions. Not applicable.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.2.2.1 Unless otherwise specified, test conditions shall be as outlined on test request documentation.

4.2.2.2 Optional: Strength of fasteners with respect to minimum material specifications may be evaluated prior to this testing by one or more of the methods outlined in GMW25, Mechanical Properties and Material Requirements for Externally Threaded Fasteners.

4.3 Instructions.

4.3.1 Review part quantities and condition.

4.3.2 Secure test part to T-slot table or fixture.

4.3.3 Select proper tool, strain gaged fastener, force washer, or fastener prepared for ultrasonic measurement, strain gaged bushing inner sleeve, and torque transducer with angle encoder.

4.3.4 Configure data acquisition system to collect torque, tension, angle, and compression data.

4.3.5 Align tool and torque transducer to prevent side loading.

4.3.6 Unless otherwise specified, test requestor is to approve test setup.

4.3.7 Take photograph or digital image of test configuration.

4.3.8 Measure and document tool free spinning speed.

4.3.9 For each sample, using feeler gages or calipers, measure and document pre-test gap between strain-gaged bushing inner sleeve and bracket or component that the inner sleeve fits into.

4.3.10 Joint should be tightened to the specifications outlined in Test Request documentation. Test shut off parameters may include but are not limited to:

4.3.10.1 One hundred ten percent (110%) of fastener proof load.

4.3.10.2 Maximum torque/angle specification target.

4.3.10.3 Joint failure.

4.3.10.4 Maximum fastener or sleeve calibrated load.

4.3.10.5 Maximum torque capability of tightening tool.

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4.3.11 Unless otherwise specified, run the first sample recording torque, tension, angle, compression, and failure mode, if any. Review with requestor and receive approval prior to proceeding.

4.3.12 If necessary, adjust the test configuration to comply with instructions of requestor.

4.3.13 Complete test matrix.

4.3.14 Summarize results similar to Section 5 of this procedure.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results.

5.2.1 Summary of Results. Required.

5.2.1.1 Provide detail of failure modes consisting of, but not limited to, fastener fracture, component fracture, component distortion or internal or external thread stripping (if applicable).

5.2.1.2 Test incidents to be recorded on Test Data Summary Sheet (similar to Appendix B, Data Sheet B1 example).

5.2.1.3 Test data summarization to be on Test Data Log Sheet (similar to Appendix C, Data Sheet C1 example), Torque vs. Tension Data Sheet (similar to Appendix D, Data Sheet D1 example), and Torque vs. Compression Data Sheet (similar to Appendix E, Data Sheet E1 example).

5.2.1.4 Required plots and tabular data tables include items in Table 1 example where:

- I Individual sample plots
- M Multiple sample plot
- D Dual Y axis plots
- S Statistical plot
- T Tabular data table followed by the incremental value

Table 1: Torque Tightening Strategy Example

Y-Axis	X-Axis							
	Torque	Tension	Angle	Compression	Load	Disp.	RPM	Time
Torque		T5	M	T5				
Tension	M		M					
Angle								
Compression	M	M						
Load								
Displacement								
RPM								

5.2.2 Summary of Results Optional. After reviewing required data summarization, requestor may ask for additional items including, but not limited to, the following.

5.2.2.1 Summary of results including, but not limited to: Upper proportional limit torques, lower proportional limit torques, maximum torques, ultimate torques, and prevailing torques (similar to Appendix F, Data Sheet F1 and/or Appendix G, Data Sheet G1 and/or Appendix H, Data Sheet H1 examples.)

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5.2.2.2 Optional plots and tabular data tables include items shown in Table 2 example where:

- I Individual sample plots
- M Multiple sample plot
- D Dual Y axis plots
- S Statistical plot
- T Tabular data table followed by the incremental value

Table 2: Torque Angle Tightening Strategy Example

Y-Axis	X-Axis						
	Torque	Tension	Angle	Compression	Load	Displacement	RPM
Torque			DDIT10				
Tension	DIS		DIT10				
Angle							
Compression	DI	I	IMT10				
Load							
Displacement							
RPM			DIM				

5.2.2.3 Magnified Scale Plots. Additional plots rescaled to magnify desired detail of curves.

5.3 Test Documentation. See Section 5.2.1.

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.