



Transmission Gear Shifter Knob Torsional Durability Test

1 Scope

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 validate the torsional durability of the interface between the gear shift lever and the gear knob.

1.2 Foreword. The primary purpose of this procedure is to provide means of validating the torsional behaviour of the interface between the gear shift lever and the gear knob in manual transmission vehicles. However it can also be used for benchmarking, development testing and to study part performance. It should be noted that this procedure is based on the suggested rig design and equipment set-up.

1.3 Applicability. This test is applicable for all vehicles with manual transmissions.

2 References

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

2.1 External Standards/Specifications.

DIN 6350

2.2 GM Standards/Specifications.

None

2.3 Additional References.

Report # 2009-07-02-62466: MY10 VE & MY10 GMX251 – Measurement of Gear Shift Lever Torque [PRD036] (External Shift System), all relevant SSTs and CTS

3 Resources

3.1 Facilities.

3.1.1 Test laboratory with power and air supply at GM, supplier or contractor premises.

3.2 Equipment.

3.2.1 Major Sub-systems. See Appendix A1.

- Sequencer
 - Power Supply
 - Core Rig
 - Actuation System
 - Data Acquisition System
- 3.2.2 Core Rig.** See Appendix A4 for sketches.

- Baseplate
- Upright, incorporating height adjustment

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- Precision self-centring chuck¹, mounted on low friction roller bearings¹
- Rig Arm, with soft contact points onto which the load cells shall act².
- Spring¹ loaded Knob Grips
- Rubberised Blank Shaft¹
- Test Piece

3.2.3 Actuation System.

- 2 x Pneumatic Solenoid Valve
- 6 x Flow Regulators¹
- 2 x Pressure Regulators¹
- 2 x Pneumatic Cylinders¹
- Pneumatic Lines¹

3.2.4 Data Acquisition System.

- Displacement Sensor¹, attached to Rig Arm via Magnet mounted on Universal Joint
- Load and Displacement Signal Conditioner (two load channels and one displacement channel.)
- Data Acquisition Computer (two load channels, one displacement channel and 200 Hz sample rate.)
- 2 x Load Cells^{1,3}

3.2.5 Critical Performance Requirements. As a whole, the set up must satisfy the following parameters:

- Clamp load at knob grips: 230 N $\pm$ 15 % (50 mm jaw opening).
- Load Cell accuracy and repeatability: $\pm$ 0.15 N up to 50 N compression loading.
- Displacement sensor accuracy and repeatability: $\pm$ 0.1 mm over 50 mm stroke.
- System resistance: $\leq$ 0.2 Nm (measured in accordance with paragraph 4.1.4.2)
- System free-play: $\leq$ 0.2°⁴ (measured in accordance with paragraph 4.1.4.3)
- Rubberised blank shall conform to Figure 1.

3.3 Test Vehicle/Test Piece. A Gear Knob and Shift Lever that has been modified to fit into chuck.

Note: Modification of the shift lever must ensure that the axis of rotation of the chuck is coincident and parallel with the axis of rotation of the gear knob and shift lever interface so that knob centroid locates approximately at the rotation axis and loading acting at the knob will be pure torque. Also, test lever shall be rigid between gear knob interface and chuck i.e. applied torque will not be transmitted through lever isolator/rubber.

¹ See Appendix A2 for the components used in the example set up. Alternative equipment may be substituted, providing that equipment fulfils the same function and complies to critical specifications.

² Soft contact between the load cells and rig arm shall be ensured to prevent signal noise that would result from metal on metal contact. In the example set-up, rubber "buttons" have been bonded to the rig arm. See Figure A2, Appendix A, paragraph A2.

³ The separation of the load cells is important because it, in part, dictates the maximum rotation the rig can achieve. In the suggested rig, the load cells have a separation of 60mm, centred at the rig arm. With this separation and the load cells acting with a 100mm moment arm, the maximum possible rotation is (24.8 $\pm$ 12.4)°, with a practical capacity of (20° $\pm$ 10)° for normal test purposes (as some allowance shall be made to prevent bottoming out).

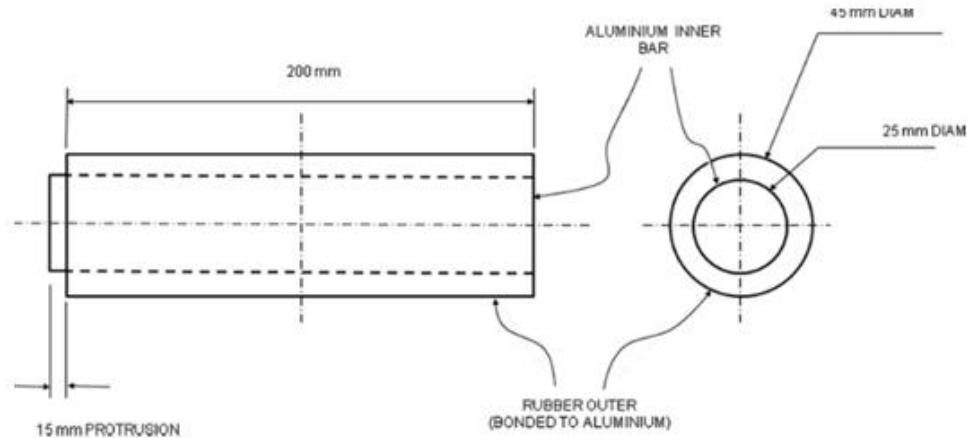
⁴ If the system freeplay is excessive, it will result in a falsely high measured freeplay of the test sample. The following contribute to system freeplay: pins locating the knob grips to upright, roller bearing under chuck and any backlash in the universal joint located at LVDT shaft (just prior to attachment magnet).

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Figure 1: Rubberised Blank



Note: Rubber shall be of (50 ± 5) Shore A Hardness.

3.4 Test Time.

Calendar time: 15 days

Test hours: 240 h

Coordination hours: 40 h

3.5 Test Required Information.

See BoD for pass/fail criteria.

For cycles 0 K to 750 K (Normal Module): $T_{spec} = 1$ Nm in each direction,

For cycles 750 K to 760 K (Abuse Module): $T_{spec} = 3.8$ Nm in each direction.

3.6 Personnel/Skills. Operator must be capable of programming sequencer, setting up pneumatics, signal conditioner and data acquisition computer and performing load cell and displacement transducer calibrations.

4 Procedure

4.1 Preparation.

4.1.1 Construct the Rig. See Appendix A, paragraph A4 for dimensioned drawings of suggested rig set-up.

4.1.2 Set up Equipment. See Appendix A, paragraph A1 – System Map of Rig Set-up.

- Connect Sequencer, Data Acquisition Computer, Signal Conditioner and power supply.
- Connect Actuation System to air supply.
- Program Sequencer.
- Set up Data Acquisition Computer.

4.1.3 Calibrate LVDT and Load Cells. Ensure LVDT and Load Cells are calibrated according to calibration report. It is recommended that the load cells be calibrated over the range (0 to 50) N in compression and the LVDT be calibrated over 50 mm.

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4.1.4 Determine System Resistance & Free Play⁵.

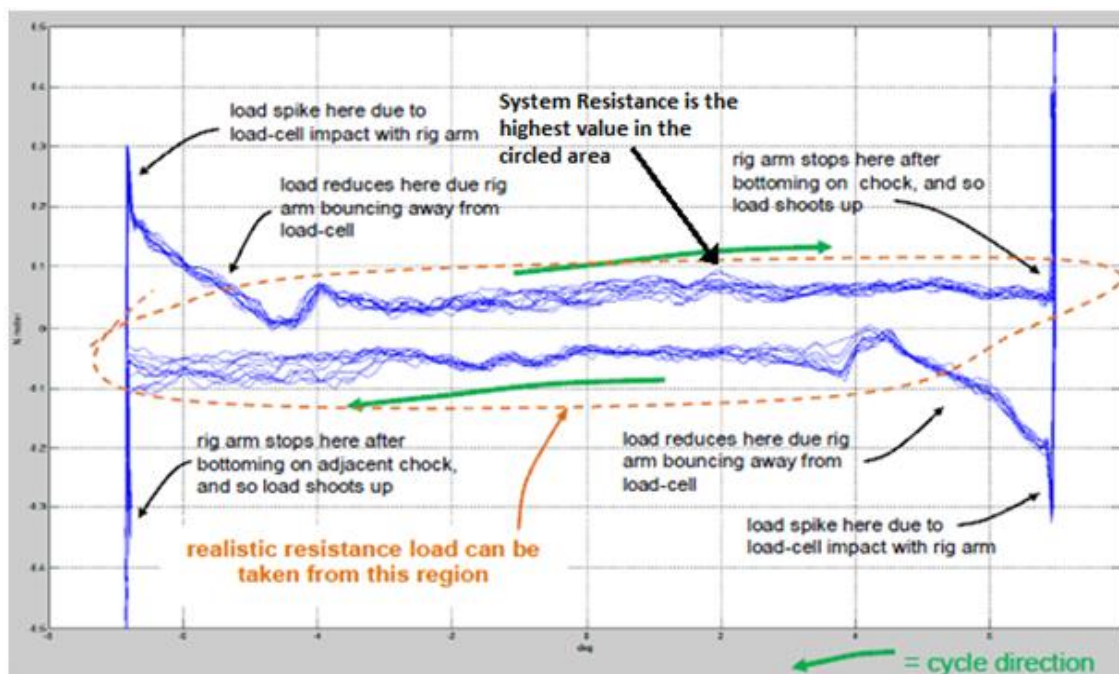
4.1.4.1 Zero Sensors.

1. Ensure the LVDT is connected to rig arm.
2. Locate the rig arm centrally⁶.
3. Ensure the loads cells are unloaded.
4. Zero sensors.

4.1.4.2 Measure System Resistance.

1. Ensure there is no impediment to the free movement of the rig arm and place chocks at 2nd widest separation.
2. Adjust Flow Regulators so the cycles are smooth, complete and pneumatic cylinders extend slowly⁷.
3. Adjust Pressure Regulators to provide the minimum pressure that allows full cycles to take place.
4. Set the sequencer so each repeat allows a full of the LH and RH cylinders, sequentially. Each cylinder should extend sufficiently to force the rig arm to bottom out on the relevant chock.
5. Cycle the rig over the largest practical displacement, recording load and deflection for at least five (5) cycles.
6. Plot Force of Actuation vs. Angular Displacement of Rig Arm to find System Resistance (see Figure 2)
7. The system resistance shall meet the requirement of paragraph 3.2.5. Possible sources of any excessive resistance include the LVDT & roller bearing.

Figure 2: Trace of the System Resistance (Torque vs. Rotation)



⁵ It is recommended this be done annually, but this can be verified at the discretion of the testing facility.

⁶ Failure to do so can result in large errors in the calculated rotation.

⁷ The slow extension of the cylinders is critical. Rapid extension will cause impact loads on contact with rig arm, which will distort the load reading

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4.1.4.3 Measure Free Play in Rig (with Rubberised Blank).

1. Stop the rig, fully retract the actuators and centre rig arm.
2. Fit rubberised blank with knob grippers at the top of their adjustment.
3. Cycle rig, ensuring that the period of the cycle is long, maximising the time between each force application, e.g. the cycle in Figure 3 shows a period of 16 s, with 7 s of zero load between each force application.⁸
4. Record load and displacement data over at least five (5) cycles.
5. Plot data to determine freeplay.
6. Stop the rig, fully retract the actuators, centre rig arm and adjust knob grippers to bottom of their adjustment.
7. Repeat steps three (3), four (4) and five (5).
8. The recorded free-play (see Figure 4) shall meet the requirement of paragraph 3.2.5.

Figure 3: Trace of moment applied to rubber blank, demonstrating the cycle to be applied.

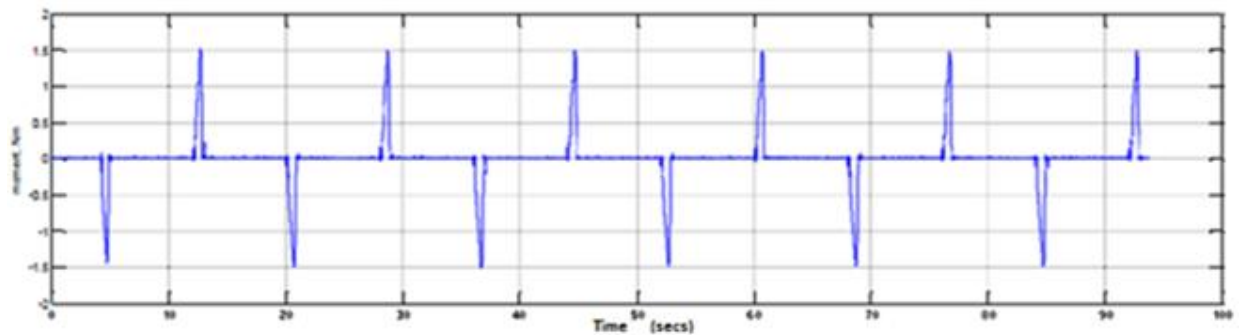
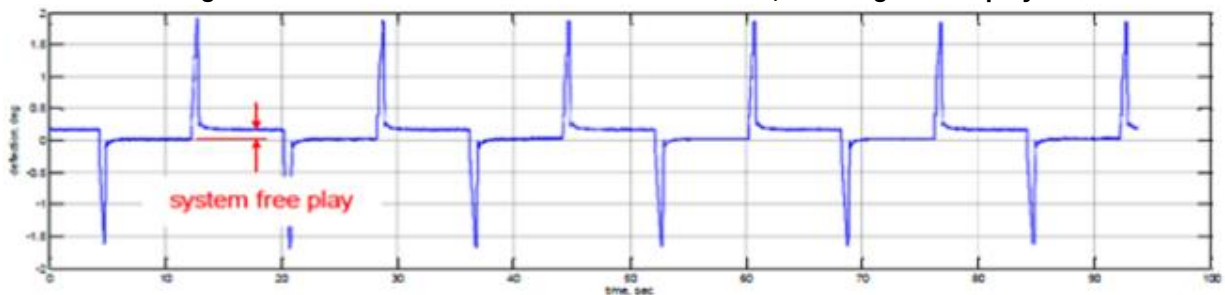


Figure 4: Trace of rotation of the rubberised blank, showing the freeplay.



4.2 Conditions.

4.2.1 Environmental Conditions. Ambient temperature (+20 to +25) °C.

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.

4.3 Instructions.

4.3.1 Zero Sensors, see paragraph 4.1.4.1.

4.3.2 Measure Pre-Test System Resistance, see paragraph 4.1.4.2.

⁸ It is important the rig cycle with a long period so the load has time to stabilise during each zero-load condition. Failure to do this will result in a large free-play measurement, due to hysteresis in the rubber.

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4.3.3 Determine Test Torque Requirement.

$$T_t = T_{\text{spec}} + T_r$$

where:

T_t = Test Torque Requirement in Nm

T_{spec} = Applied Torque Specification according to paragraph 3.5 in Nm

T_r = Measured System Resistance⁹ according to paragraph 4.3.2 in Nm

An additional allowance may be added to T_t to allow for measurement uncertainty, at the test facility's discretion.

4.3.4 Determine Test Torque Setting.

$$T_s = 1.05 \times T_t \text{ OR}$$

$$T_s = T_t + 0.08 \text{ Nm, whichever is greater.}$$

where:

T_s = The Test Torque Setting to be used in Nm

T_t = The Test Torque Requirement according to paragraph 4.3.3 in Nm

Note: T_s is used to account for possible load and system resistance fluctuations.

4.3.5 Fit Test Sample.

1. Stop the rig and fully retract the actuators.
2. Place the chocks at their narrowest separation to centrally locate the rig arm.
3. Open the grippers and install an auxiliary clamp to hold them open.
4. Place modified shift lever and knob in the self-centring chuck and then tighten the chuck.
5. Adjust the grippers so that the centre of the grippers locates around the knob at its maximum diameter.
6. Remove the auxiliary clamp so that the grippers firmly hold the gear knob, chuck and rig arm in place.

4.3.6 Make Sequencer, Flow and Pressure Regulator Adjustments.

1. With the chocks still in place, adjust the pressure regulators so there is enough force to cycle rig.
2. Set up sequence to achieve a cycle period of ≥ 1.25 s.
3. Ensure that each cylinder acts sequentially with a short interval of zero-load (relaxation time, t_r) in between each cylinder's acting on the rig arm. Ensure each of these relaxation times are < 0.5 s (see Figure 5). This is best achieved by setting the flow regulator to achieve rapid retraction and smooth expansion. At no point shall both cylinders expand onto rig arm at the same time.
4. Place the chocks at their furthest separation.
5. Initiate the cycling of the rig.
6. Adjust the pressure regulators until the Test Torque Setting (T_s) for the Normal Test Module is reached or slightly exceeded.
It may be necessary to fine-tune the flow regulators as the pressure is increased.
7. Check again that the cylinders are acting sequentially and never bearing onto rig arm at same time.

Note: Special care must be taken when adjusting pressure to achieve T_s . Significantly overloading test sample will render test sample invalid for testing.

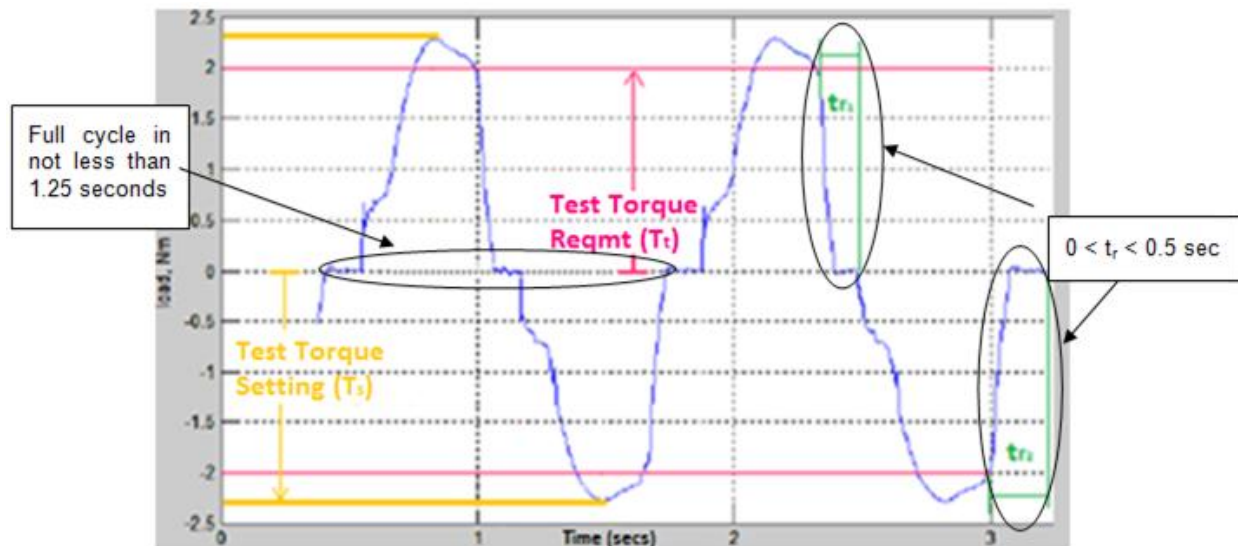
⁹ The test facility may choose to assume a value larger than that measured, based on previous readings and knowledge of resistance variation

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Figure 5: Visual Representation of Two Test Cycles, Annotated With Key Parameters



4.3.7 Perform Durability Normal Test Module. Ensure that Sequencer, Flow Regulators and Pressure Regulators are set correctly, and then start the test.

During the test, data is not continuously collected, rather, the test is monitored regularly and data is collected at intervals as detailed in paragraph 4.3.9.

The rig shall be regularly monitored to ensure:

- the load magnitude at the load cell is not less than T_s , but also not excessive.
- there is no slippage of the knob lever in the chuck.
- the movement arc of the rig arm is not impeded¹⁰.
- This monitoring will require judgment from the operator. For example, the sample may require hourly monitoring to begin with as it beds in, but less and less as the test goes on.

Important: Once durability test has commenced, do not disturb test sample or grippers until test is complete¹¹.

4.3.8 Perform Abuse Test Module.

1. Increase the pressure at the pressure regulators until the Test Torque Setting for the Abuse module is reached slightly exceeded.
2. Repeat paragraph 4.3.7.

4.3.9 Data Collection.

- Data will be collected as requested by test engineer.
- Suggested data collection is at 0 %, 20 %, 40 %, 60 %, 80 % and 100 % completion of durability module.
- Additionally, data should be collected after the abuse module.
- When collecting cycle data, record five consecutive cycles, to ensure consistency of results.
- If the rig has not been cycling prior to data collection, allow the rig to run for 20 cycles before collecting data to ensure the test sample has stabilised. This includes the 0 % data collection.
- Each dataset will include the following recorded channels synchronised in time the domain:

F_1 = Force in load cell 1 (in N)

¹⁰ Pay particular attention to make sure there is no bottoming of rig arm onto adjacent chock or load cell.

¹¹ If non-symmetrical rotation could cause the rig arm to potentially bottom out against adjacent load cell, the knob will have to be disturbed to 're-zero' position in the grips to centralise the rotation arc.

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F_2 = Force in load cell 2 (in N)

d = Linear Displacement in direction 1 (in mm)

- These parameters need conversion to angular units before analysis vs specifications (see Appendix B, paragraph B1)

4.3.10 Measure Post-Test System Resistance. Repeat paragraph 4.3.2.

4.3.11 Re-Calculate Test Torque Requirement. Repeat paragraph 4.3.3, using whichever System Resistance is higher between that acquired from paragraph 4.3.2 and 4.3.10.

4.3.12 Create History Traces From Data.

Torque Time History: Recorded Linear Load x Moment Arm Length vs. Time. (see Appendix C, paragraph C3.1)

Rotation Time History: Angular Displacement of Sample vs. Time. (see Appendix C, paragraph C3.2)

Assembly Rigidity Profile: Moment applied to sample vs. Angular Displacement of sample (see Appendix C, paragraph C3.3)

5 Data

5.1 Calculations.

- Linear results are recorded by Load Cells and LVDT
- Combine the data from the load cells into one piece of data: $F = F_1 + F_2$, where $F_1 > 0$ & $F_2 < 0$
- Convert data from linear units to angular units. (see Appendix B, paragraph B1.1)
- Check validity of data against rules: $|T_1|$ & $|T_2| > L_t$ AND $0 < t_{r1}$ & $t_{r2} < 0.5$ s.
- Determine the freeplay of each cycle (see Appendix B, paragraph B1.2)
- Determine the torsional elasticity of each cycle (see Appendix B, paragraph B1.3)
- Determine the average freeplay and torsional elasticity and assess against pass/fail criteria (see paragraph 5.2)

5.2 Interpretation of Results. For the sample to pass the following criteria must be met:

- $Y < Y_{spec}$
- $E < E_{spec}$
- $E. < E_{spec}$

5.3 Test Documentation. Not applicable.

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 Notes

7.1 Glossary.

Cycle = From the 'zero position', apply force in one direction and then release, then apply force in opposite direction and then release.

7.2 Acronyms, Abbreviations, and Symbols.

F = Force at any particular point in time (in N)

F_1 = Force from load cell 1 (in N)

F_2 = Force from load cell 2 (in N)

A = Moment Arm to Load Cells (in m)

a = Moment Arm to LVDT (in mm)

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