



Manual Transmission Durability on Bench

1 Scope

Note: Nothing in this standard supersedes 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. This standard provides the test requirements for validating the overall reliability of the gearbox and/or of its components and subsystems.

1.2 Foreword. This standard reflects 160 000 km ($\approx$ 100 000 miles) severe customer usage and it is sufficient to deliver durability of gears / shafts / bearings / lubrication and all rotating parts excluding:

- Synchronizer devices and internal shifting system that have specific test requirement
- Differential assembly and casing that need further test in order to verify strength under dynamic conditions (abuse tests)
- Reverse gear that needs further test in order to verify strength under dynamic conditions (abuse test)

1.3 Applicability. This Test Procedure is applicable for vehicles with GVW $\leq$ 3000 kg (no trucks).

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

None

2.3 Additional References.

2.3.1 Security. Except as noted in the following list, none of the text, procedures, tables, or numbers in this document or associated documents may be released outside GM Powertrain. If an outside Company has to

conduct testing based on this procedure, the following information may be released:

- The required content of the test (how many hours/cycles, the speeds, the temperatures, etc.), or a separate document which gives this information.
- The test reliability (and associated confidence) to be demonstrated on the test.
- The required sample size.
- Recommendations for continued testing for failure and for analysis of the results.
- Requirements for reporting the test results to GM Powertrain.

Information about how the test was determined **may not** be released. For example, background on how the test inputs were selected (such as the customer severity being represented) or the field reliability that corresponds to the required test reliability, **may not** be released.

Information about how the test parameters values (speeds, temperatures, etc) were determined **may not** be released.

3 Resources

3.1 Facilities. Electric dyno or combustion dyno shall be applied.

3.2 Equipment.

3.2.1 Engine. This test can be performed either with a combustion engine or electric engine, which is able to deliver torque, power and engine speed values required. The engine speed (RPM in the following) range shall accommodate the peak torque rating of the engine / application (but not less than 3000 min⁻¹ at input).

Note: If a combustion engine is used it is necessary to adapt the test bench to refrain the engine, with all the base equipments:

- A Servo motor for throttle valve actuation.
- B Test shall be performed by
 - throttle / out speed control or
 - torque / out speed control.

3.2.2 Gearbox Control Unit. Control unit consisting of:

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A Shift robot for shift lever actuation.

B Servo motor for clutch actuation.

3.2.3 Transmission Monitoring Unit. Procurement of the necessary equipment used to measure the data in paragraph 5.1. In particular:

A Monitoring for engine speed, transmission output speed.

B Transmission oil temperature monitoring.

C Half-shafts torque.

3.2.4 Test Equipment.

A Transmission with drive shaft.

B Exchangeable flywheel mass stepped.

C External gear shift system.

D Fan unit to ensure transmission cooling.

E Structure-borne noise monitoring and/or analysis system.

3.2.5 Shut Down Devices. For transmission safety please note:

3.2.5.1 Shut-Down Types and Alarm.

Note: Shut-down types and alarms depend mainly on the test controller model. Here, as reference, a general method is given.

3.2.5.2 Alarm Limits. Alarm values are given as reference only: They depend on the type of engine, on the components limits. So the actual alarm values shall be fixed by the Test Engineer.

3.2.5.2.1 Oil temperature.

- Alarm limit at +115 °C
- Shut down limit at +120 °C

3.2.5.2.2 Engine Speed. Shut down limit at 500 min⁻¹ above maximum speed.

3.2.6 Recordings Post Mortem. Record of half-shafts, engine speed, temperature, gear engaged, throttle position, input torque or half-shafts torque of the last few minutes shall be available.

3.2.7 Automatic Data Acquisition Equipment. Shall be capable of a 0.1 Hz minimum raw signal sample rate (see paragraph 5.1).

3.3 Test Vehicle/Test Piece.

3.3.1 Transmission. Procure a new transmission, complete with accessories, same as on vehicle, or ensure that all the parts needed for transmission are available.

3.3.2 Fluids. Factory fill amount (production intent for model year of system being tested) gearbox oil has to be used.

3.4 Test Time.

Calendar time: 2 to 3 weeks depending on transmission and engine application

Technician/
Mechanical/hours: 15 hours

Preparation,
documentation,
evaluation hours: 15 hours

3.5 Test Required Information. Possible sources are:

- SOR
- VTS (Vehicle Technical Specifications)
- SSTS (Sub System Technical Specifications)
- Application engineer
- Development group unless otherwise indicated below
- Drawings
- Wheel slip limit torque in 1st gear
- Engine performances (torque and power vs. engine speed)
- Virtual validation analysis

Note: This data may change during a transmission program or from model year to model year; make sure the data is updated.

3.6 Personnel/Skills. Not applicable.

4 Procedure

4.1 Preparation.

4.1.1 The following measurements (characteristics of components) shall be performed before and after testing:

- Axial gear play
- Teeth profile

4.1.2 Assemble the transmission on bench ensuring the correct position as in the vehicle.

4.1.3 Apply a thermocouple on the oil drain plug.

4.1.4 Fill the gearbox with the correct quantity and type of oil (see paragraph 3.2).

4.1.5 Select the correct flywheel mass.

4.1.6 Adjust the gear shifting, clutch and throttle controls.

4.2 Conditions.

4.2.1 Environmental Conditions. Fulfillment of test requirements must be ensured.

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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 General. Take care to not overload transmission during start procedure by torque impact.

Take care for the right assembling position of the transmission unit specified by vehicle package.

Take care for possible torque limits in several gears.

During the whole test the temperature value of transmission oil shall be kept preferably at (+90 to +110) °C and monitored. Do not heat to reach temperature interval.

4.3.2 Test execution.

4.3.2.1 Running-In. Perform Running-In Cycles according to Appendix A, paragraph A.1, if necessary.

4.3.2.2 Test in Drive. Calculate duration of each step according to Appendix A, paragraphs A.2 and A.3 to fulfill the defined test requirements.

Use input RPM according to peak torque of the particular transmission / engine application (but $\geq 3000 \text{ min}^{-1}$).

4.3.2.3 During the whole test, check that the average torque measured at the half-shaft is $\leq 10 \%$ compared to its value at the beginning of test.

4.3.3 After test, the transmission shall be disassembled and all the residual torque of each threaded connection shall be measured using a torque wrench.

4.3.4 Repeat test 2 times for 3 acceptable results.

5 Data

5.1 Calculations.

5.1.1 Minimum Required Data. The following data shall be recorded at least every 10^{th} cycle (the Test Engineer may require additional data) for each gear:

- Engine speed (in min^{-1})
- Theoretic torque
- Real torque
- Oil temperature
- Engine type / engine km (mileage)

5.2 Interpretation of Results.

5.2.1 Evaluation Criteria.

5.2.1.1 Gears, Hubs, Sleeves, Shafts.

5.2.1.1.1 Breakage. No breakage is permitted.

5.2.1.1.2 Wear. Refer to SSTS for wear in comparison to the beginning of the test.

5.2.1.1.3 Pitting. Refer to SSTS for pitting. For every pitting contact Design Responsible Engineer to find root cause and solution to avoid.

5.2.1.2 Bearings.

5.2.1.2.1 Breakage. No breakage is permitted.

5.2.1.2.2 Wear. No wear on the shoulders or races is permitted. No axial movement of the inner ring bearings on shaft seats is permitted. Rotation of the bearings on the shaft seats is permitted as long as there is no wearing. The play after testing is subject to verification by the leading supplier.

5.2.1.2.3 Pitting. No trace of pitting is permitted.

5.2.1.2.4 Integrity. All parts of the bearings shall be integral (rings, cages, races). A slight burnishing of the rolling races is permitted.

5.2.1.3 Casings.

5.2.1.3.1 Integrity. No breakage / cracking is permitted. No bearing seat shall show seizing marks. The bearings may rotate in their seats on the casing as long as there is no wear.

5.3 Test Documentation.

5.3.1 Transmission Data. Record name and number of all parts removed or installed (model year, gear, reduction and overall ratio, type of oil and quantity, type of tire - width / shoulder / rolling radius), cell and transmission numbers, test hours on part and on transmission, together with reason part was eventual removed.

5.3.2 Comment. Report a detailed comment of the transmission performance and of individual components (shafts, bearings, etc.), based on the photos of disassembled transmission and on observations made during the test.

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