



Low Frequency Fore/Aft “Chuggle” Vibration Measurement

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. The purpose of this procedure is to measure low frequency fore/aft vehicle vibrations (“chuggle”) resulting from powertrain-induced random torque excitations. Chuggle vibration is most noticeable on smooth roads with torque converter locked during light acceleration run-up or tip-in events. The source of chuggle vibrations can be both random and periodic related to cycle-cycle variations and cylinder-cylinder balance, respectively. This procedure will focus on chuggle due to random torque excitations of the 1st driveline torsional mode (path) and vehicle/body (response). Periodic chuggle is currently under-study and may be added to this procedure at the first refresh.

1.2 Applicability. This test procedure is applicable to all drivetrain configurations (FWD, RWD and AWD), including manual and automatic transmissions.

1.3 Remarks. Not applicable.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14264

2.3 Additional References.

- INCA/ETAS hardware/software available at www.etas.com
- LMS Test.Lab software, SCADAS Mobile and SCADAS XS software, available from Siemens PLM Software, www.plm.automation.siemens.com
- NEOVI hardware, available at Milford Proving Grounds (MPG) Building 94 chassis rolls test office or drive quality group (contact the GM Lead Engineer for further instructions).
- VSPY software, available from Information Technology (IT) group or MPG Building 94 chassis rolls test office or drive quality group (contact the GM Lead Engineer for further instructions).

3 Resources

3.1 Facilities. Smooth flat road (Noise and Vibration (N&V) Noise Roads or Straightaways)

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 Tachometer. A High pulse-per-revolution engine tachometer signal is required for this testing. It is recommended to use the Engine Control Module (ECM) harness with 58X (engine Rotations per Minute (eRPM))

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Bayonet Neill-Concelman (BNC) lead. The harness for a particular engine can be signed out from Global Propulsion Systems N&V Integration Group or a harness can be made with the help of electrical test group. A high pulse count signal is required for Fast Fourier Transform (FFT) analysis of engine RPM signal to determine the frequency of 1st drivetrain torsional mode.

3.2.2 G-meter. An Analog or digital meter may be used to monitor acceleration rate during testing event.

3.2.3 VSPY/NEOVI. VSPY/NEOVI (see 2.3) or INCA (see 2.3) is needed to fix transmission gear position and lockup torque converter for the test.

3.2.4 Accelerometers. One (1) triaxial low mass accelerometer with flat response from 2 Hz to 2000 Hz and operating range of 10 °C to 50 °C are required. Additional accelerometers may be used for reference if desired.

3.2.5 Data Acquisition Equipment. The preferred digital data acquisition system is a personal computer running LMS Test.Lab software connected to SCADAS (Mobile or XS) front end (available from www.plm.automation.siemens.com) (or equivalent) as approved by the Global Noise and Vibration Center (GNVC) Infrastructure Team. This setup allows simultaneous digital recording of time domain data and online or post processing of frequency and order domain data.

3.3 Test Vehicle/Test Piece. Not applicable.

3.4 Test Time.

Calendar time: 2 days

Test time: 2 hours

Coordination time: 8 to 12 hours

3.5 Test Required Information. The following information is required to run this procedure.

3.5.1 Operating Conditions (Pseudo Constant Torque Acceleration).

1. Condition 1:

- a. Smooth flat road surface
- b. Locked in transmission gear (Continuously Variable Transmission (CVT) fixed gear ratio) that corresponds to 1000 eRPM to 2000 eRPM sweep for a road speed range of 20 mph to 70 mph at 0.04G acceleration rate
- c. Torque converter locked

2. Condition 2:

- a. Repeat **Condition 1** with torque converter lockup as scheduled via base ECM/Transmission Control Module (TCM) calibration

3.6 Personnel/Skills. One (1) qualified engineer or technician trained in the use of data acquisition and recording equipment with basic knowledge of digital signal processing of vibration signals. Experience using LMS Test.Lab and VSPY for on-road acquisition is also helpful. One (1) driver to perform the vehicle operation and subjective evaluations.

4 Procedure

4.1 Preparation.

4.1.1 Vehicle Preparation. Vehicle shall be tested at full tank of gas and tire pressures set to specifications.

4.1.2 Vehicle Instrumentation.

4.1.2.1 Engine RPM (eRPM) Tachometer. Install ECM jumper harness with 58X signal output lead as shown in Appendix A, Figure A1. Using BNC connector attach cable to data acquisition RPM input. In LMS Test.Lab tachometer setup, enter 60 pulses per revolution. Perform "TACHO_MOMENTS_CORRECTION" to 58X signal using time signal calculator (see Appendix A, Figure A2). Correcting the tachometer moments will account for two (2) missing pulses in the pulse train.

4.1.2.2 Accelerometers. Install one (1) triaxial accelerometer on the front inboard seat track (see Appendix A, Figure A3). Additional accelerometers can be added for reference including engine top, engine lower near each half shaft connections, driveline mounts and suspension mounting points.)

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4.1.3 NEOVI. Use Onboard Diagnostics (OBD2) connector, NEOVI and VSPY software to lock transmission gear position and torque converter (reference pictures in Appendix A, Figure A4).

4.1.4 INCA. As an alternative to NEOVI, INCA with an instrumented Transmission Control Module (TCM) can be used to control the Commanded Gear, Torque Converter Clutch (TCC) State (force lock), and TCC Pressure.

4.2 Conditions.

4.2.1 Environmental Conditions. Track surface should be dry and free of snow/salt. Warm ($> 25^{\circ}\text{C}$), humid ($> 85\%$ relative humidity) weather is ideal because it tends to demonstrate the worst conditions for engine combustion.

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 Vehicle Warm Up. Prior to collecting data, drive the vehicle for approximately 15 minutes so the powertrain mounts, suspension bushings, engine oil and transmission oil are at operating temperatures (do not start testing until transmission fluid is at normal operating temperature).

4.3.2 Test Procedure. Proceed to flat smooth road surface (NorthSouth or EastWest straightaway or Noise Road at Milford Proving Grounds (MPG) or equivalent).

4.3.2.1 Subjective Evaluation. Note Subjective Scale ratings per GMW14264 for each operating condition as outlined in 3.5.1. Reference Appendix A, Table A1 for Subjective Scale ratings vs. measured vibration levels.

4.3.2.2 Objective Measurements. Maintain cruising speed in high gear (5th gear equivalent ratio for 6-speed Automatic Transmission (6AT)) with torque converter locked at around 1100 eRPM and accelerate slowly at 0.04G until engine speed reaches 2000 RPM. In order to maintain a constant torque, it is necessary to lightly tip-in at the beginning of sweep and gradually increase pedal percentage to maintain constant 0.04G acceleration/torque level (avoid going too deep into the pedal and tipping out to maintain acceleration rate). Occasionally the torque converter may slip/re-lock causing a transient shudder, if this occurs the test run must be repeated. This occurs because VSPY doesn't allow the user to change clutch line pressure to avoid slip. Note that with INCA instrumentation and instrumented TCM, the gear state, TCC state, and TCC pressure can all be controlled.

5 Data

5.1 Calculations.

5.1.1 Data Collection Parameters.

- Tracking setup: Tracked tachometer with "UP" slope method from 1000 eRPM to 2000 eRPM
- Increment for tachometer: 5 RPM
- Acquisition setup: Sampling frequency of 512 Hz with 1 Hz resolution
- Window type: Hanning
- Online processing: Save Waterfalls
- Measure: Save throughput data (time data)

5.2 Interpretation of Results.

 Not applicable.

5.3 Test Documentation.

5.3.1 Data Post Processing.

1. Correct 58X pulse train per the methods covered in 4.1.2.1 and Appendix A, Figure A2 (if applicable);
2. Observe waterfall plot for seat track fore/aft vibration to determine what frequency the 1st torsional mode occurs at (generally around 5 Hz to 7 Hz range in higher gear), reference Appendix A, Figure A5;
3. In time data processing, apply a band-pass filter approximately 5 Hz wide since desired information is in vibration caused by the 1st torsional mode of the drivetrain, reference Appendix A, Figures A6 and A7;
4. Utilize time tracking method with 0.333 s increment along with 1 Hz (1st time block) and Hanning window to get sufficient time segment overlap and smoother data traces;
5. Calculate band-pass Overall level Root Mean Square (RMS) for response channels;
6. Present data in acceleration or decibels (dB) RMS (un-weighted) as a function of engine speed, reference Appendix A, Figure A6.

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