



Exhaust System Flexible Decoupling Element Static Characteristics and Structural Durability

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. This procedure describes the component level validation tests for an exhaust system flexible decoupling element with regard to its static characteristics and structural durability.

1.2 Foreword. The validation of a flexible decoupling element includes the determination and evaluation of its static characteristics as well as the evaluation of its durability when subjected to real time load and displacement profiles. A road load data acquisition (RLDA) is required to define the real time load and displacement profiles of the applicable road test modules.

1.3 Applicability. This procedure is applicable to all passenger cars, sport utility vehicles and light trucks equipped with a load bearing or non-load bearing flexible decoupling element.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW15261

2.3 Additional References.

Component Technical Specification (CTS)

Palmgren-Miner Rule

Subsystem Technical Specification (SSTS)

Vehicle Technical Specification (VTS)

3 Resources

3.1 Facilities.

Note: This procedure assumes adequate physical testing facilities and infrastructure for flexible decoupling element structural durability testing are available. The following paragraphs provide a partial list of the major facilities required.

3.1.1 Static Characteristics Tests. Not applicable.

3.1.2 Road Load Data Acquisition. The RLDA shall be executed on a GM Proving Ground.

3.1.3 Durability Test. Not applicable.

3.2 Equipment.

3.2.1 Static Characteristics Tests.

3.2.1.1 Push/Pull Test Installation. A push/pull test installation with closed loop feedback control and analysis system is required. It shall be equipped with a displacement control providing a maximum error of ± 0.01 mm and with a force control providing a maximum error of ± 0.1 N. All equipment shall be calibrated.

3.2.2 RLDA.

3.2.2.1 Transducers. All transducers shall be calibrated.

3.2.2.1.1 Acceleration Transducers. Cooled, tri-axial accelerometers with measurement range of 1 m/s² to 200 m/s², scan rate $\geq$ 2400 Hz, maximum error $\pm$ 0.1 m/s², typical input range $\pm$ 25G, 0 Hz to 500 Hz, shall be used to collect acceleration data at the specified locations.

3.2.2.1.2 Displacement Transducers. String potentiometers (range $\pm$ 50 mm) with a maximum error of $\pm$ 0.1 mm and a scan rate $\geq$ 300 Hz shall be used to measure the flexible decoupling element displacements at the specified locations.

3.2.2.2 Transducer Signal Conditioner. Transducer signal conditioners are used to condition signal inputs from the remote parameter transducers. At the start of the RLDA, transducer information files are created, which define the gain, full scale, calibration, excitation, and sensitivity for each transducer. This information shall be saved and transferred to the test lab along with the remote parameter transducers. This allows the use of the same transducers and transducer signal conditioner parameters during the test development.

3.2.3 Durability Test.

3.2.3.1 Hot Gas Burner. The hot gas burner shall be capable of providing sufficient hot gas in order to ensure a realistic temperature distribution in the flexible decoupling element during the durability test.

3.2.3.2 Force/Displacement/Angle Controlled Test Installation. A force/displacement/angle controlled test installation with closed loop feedback control and an analysis system capable of representing the measured kinematic exhaust system maximum displacements in all six (6) degrees of freedom shall be used.

3.2.3.3 Transducers. All transducers shall be calibrated. The transducer measurement range shall be defined based on the expected measurement results. Maximum transducer errors are defined in the following paragraphs.

3.2.3.3.1 Force Transducers. The force measurement shall have an error of $<$ 5% of the measurement range.

3.2.3.3.2 Displacement Transducers. The displacement measurement shall have an error of $<$ 5% of the measurement range.

3.2.3.3.3 Angular Transducers. The angle measurement shall have an error of $<$ 5% of the measurement range.

3.2.3.3.4 Transducer Signal Conditioner. Transducer signal conditioners may be used to condition signal inputs from the remote parameter transducers during the RLDA as well as for the test development. Transducer information files are created at the start of the RLDA, which defines the gain, full scale, calibration, excitation, and sensitivity for each transducer. This information is saved and transferred to the test lab along with the remote parameter transducers. This allows the use of the same transducers and transducer signal conditioner parameters during the test development.

3.3 Test Vehicle/Test Piece.

3.3.1 Test Vehicle. The RLDA requires a test vehicle. It must be equipped with functional and representative exhaust system, powertrain, suspension, anti-lock brake system (ABS), traction control or any other feature that might have a significant impact on flexible decoupling element movements. Deviations must be documented and reviewed with regard to potential influence on the measurement.

3.3.2 Test Samples. Only production design intent flexible decoupling elements which meet the Exhaust SSTS noise and vibration requirements shall be used. Inliners/interlocks or equivalent parts may be removed for the RLDA. Deviations must be documented and agreed upon.

3.4 Test Time.

3.4.1 Static Characteristics Tests.

Calendar time:	1 day
Test hours:	8 hours
Coordination hours:	1 hour

3.4.2 Road Load Data Acquisition.

Calendar time:	3 days
Test hours:	24 hours
Coordination hours:	2 hours

3.4.3 Durability Test.

Calendar time:	2 to 6 weeks
Test hours:	200 to 600 hours
Coordination hours:	6 hours

The durability test time depends on the applied road test module.

3.5 Test Required Information.

3.5.1 Static Characteristics Test. Not applicable.

3.5.2 RLDA. Not applicable.

3.5.3 Durability Test.

3.5.3.1 Test Specifications.

3.5.3.1.1 Applicable Road Test Modules. Applicable road test modules are defined within the VTS and the Exhaust SSTs.

3.5.3.1.2 Operation Conditions. Exhaust system operation conditions are described within the Exhaust SSTs. In particular, the required gas flow and gas temperature shall be taken from the Exhaust SSTs. Deviations from these requirements shall be approved by the GM design release engineer and the GM validation engineer.

3.5.3.1.3 Test Duration. The test duration is defined within the Exhaust SSTs. Deviations from these requirements shall be approved by the GM design release engineer and the GM validation engineer.

3.5.3.2 Road Time History Data. Preferably, data should be provided to the test lab in Remote Parameter Control 3 (RPC) format having 2048 points per group, 2048 points per frame, and 409.6 samples per second. Alternative methods shall be documented and agreed upon.

3.6 Personnel/Skills. Not applicable.

4 Procedure

4.1 Preparation.

4.1.1 Conditioning of Test Samples. Test sample conditioning is defined in the following paragraphs, the CTS or on the drawing.

4.1.1.1 Static Characteristics Test. Test samples shall be preconditioned by a setting cycle. During the setting cycle, the allowable working range of the flexible decoupling elements must not be exceeded.

4.1.1.2 RLDA. Not applicable.

4.1.1.3 Durability Test. Not applicable.

4.1.2 Shipping and Handling Provisions. Exhaust system assemblies incorporating a flexible decoupling element must be handled carefully with regard to bending, elongation, stretching, compression, and lateral displacement of the decoupling element. They require a transportation fastening for the flexible decoupling element unless installed in the vehicle or on the test bench.

4.1.3 Test Setup.

4.1.3.1 Static Characteristics Test. The flexible decoupling element shall be attached to the test bench so that the retention of the flexible decoupling element ends remains rigid. The decoupling element shall be installed tension-free at its specified nominal length.

4.1.3.1.1 Axial Characteristics. The flexible decoupling element shall be installed in the respective test fixture under consideration of its nominal length. The retainers shall be made such that a stiff and rigid connection is assured. Tension-free installation of the flexible decoupling element must be assured. See Figure A3, Appendix A, for a schematic test setup. Balancing of the fixture and test component masses is required.

4.1.3.1.1.1 Installation Position. The test sample shall be aligned such that the design centerline is in the position shown in Figure A3, Appendix A.

4.1.3.1.2 Lateral Characteristics. The flexible decoupling element shall be installed in the respective test fixture under consideration of its nominal length. The retainers shall be made such that a stiff and rigid connection is assured. Tension-free installation of the flexible decoupling element must be assured. See Figure A4, Appendix A, for a typical test setup without length compensation. During the measurement, the ends of the flexible element must move in parallel. Its alignment shall be assured by the geometry of the fixture. Balancing of the fixture and the test component masses is required.

4.1.3.1.2.1 Installation Position. The test sample shall be aligned such that the design centerline is in the position shown in Figure A4, Appendix A.

4.1.3.2 RLDA. The exhaust system's position in the RLDA vehicle must be documented with appropriate dimensions and the documentation must be provided to the test lab for duplication on the test rig. The flexible decoupling element shall be fitted with sensors according to 4.1.4.2. Clearance of the sensors, wiring, and retaining fixtures in the specified installed position must be assured during the measurements. See Figure A1, Appendix A, for a typical RLDA test setup with inductive transducers on the flexible decoupling element.

4.1.3.2.1 Installation position. Exhaust system and flexible decoupling element shall be installed in nominal position as specified by the corresponding math data or drawing. The flexible decoupling element's position shall be measured before the test start and any deviation from the nominal position shall be documented. Optionally, a worst case condition under consideration of installation tolerances might be defined. Then the exhaust system and flexible decoupling element shall be prepared and installed accordingly. GM design release engineer and validation engineer must approve any installation deviating from nominal position.

4.1.3.3 Durability Test. The test setup must not be deformed by the movement behavior of the flexible decoupling element during the test execution. Test fixture masses (inertia masses) must be considered during measurements and tests. Test sample retention must be such that flexible decoupling element movement and connections are not impaired. During test development the flexible decoupling element shall be fitted with sensors according to 4.1.4.3. Sufficient clearances in the test and measuring installation must be assured. Figure A2, Appendix A, shows a possible measuring variant with inductive transducers on the flexible pipe. See Figure A5, Appendix A, for a typical flexible decoupling element test setup.

4.1.4 Transducer Configuration. The position of the transducers shall be recorded and documented by photograph.

4.1.4.1 Static Characteristics Test. Not applicable.

4.1.4.2 RLDA. Transducers as specified under 3.2.2.1 shall be used. Low frequency movements are measured by recording the relative displacement between the flexible decoupling element inlet and outlet in six (6) directions, and the relative displacement between vehicle underbody and decoupling element outlet in vehicle driving direction. If the exhaust system configuration prevents the exhaust system from moving in driving direction, it is not required to record the relative displacement to the vehicle underbody. High frequency vibrations are measured with accelerometers by recording the tri-axial acceleration at the inlet and outlet of the flexible decoupling element. Any deviations shall be agreed upon and must be documented prior to the beginning of measurements.

4.1.4.3 Durability Test. During test bench signal verification the test sample shall be equipped with sensors according to 3.2.2.1, excluding the displacement transducer measuring the relative movement to the vehicle underbody. Figure A2, Appendix A shows an example transducer installation.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 Test Development Environmental Conditions. Typical environmental conditions are the temperature, humidity, and pressure at the test facility. Unless otherwise noted, these conditions are typically $22\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$, relative humidity of $40\% \pm 20\%$, and atmospheric pressure equivalent to the local barometric pressure.

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 Static Characteristics Test.