Master Test Procedure for Determination of Dynamic Stiffness and Loss Angle of Elastomeric Components

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 determine the dynamic stiffness and loss angle (viscoelastic properties) of elastomeric components used in vehicles when subjected to forced sinusoidal oscillations in the temperature range of -50 °C to +150 °C.

1.2 Applicability. This procedure is appropriate for the evaluation of all elastomeric components.

1.3 Remarks. The dynamic stiffness and loss angle characteristics of elastomeric components in the vehicle chassis are important contributors to vehicle noise and vibration isolation as well as ride and handling performance.

2 References

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

2.1 External Standards/Specifications.

DIN 53513	ISO 10846	SAE J1085	VDA 675480

2.2 GM Standards/Specifications.

GMW14116	GMW14203

3 Resources

3.1 Facilities.

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 Test Device. The test device shall be capable of applying both a static and a sinusoidal force to the elastomeric component simultaneously. The static force, dynamic deflection and its frequency and the temperature of the elastomeric component shall all be capable of being controlled and variable. The device consists of the testing machine (load-frame, actuators, and sensors), and measuring and analysis systems.

3.2.1.1 Testing Machine. For the parameter determination of elastomeric parts, a testing machine has to be chosen according to the part-specific conditions. The given static and dynamic loads for the elastomeric parts have to be applied by the testing machine. The machine typically has a servo hydraulic cylinder; sometimes an electro-dynamic system is used.

A testing machine for elastomeric parts must generally exhibit the following performance capability.

- Force: ± 10 kN.
- Displacement: ± 10 mm (± 20 mm is desired).
- Frequency: 0.01 Hz to 600 Hz.

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Common transducer signals used in forced non-resonant systems for obtaining data are load, displacement, and/or velocity. Each transducer should be calibrated to the following minimum accuracies.

- Force measurement: ± 0.5% of full scale for each calibrated range.
- Displacement: ± 0.5% of full scale for each calibrated range.
- Velocity: ± 0.1% of full scale for each calibrated range.

Readout instrumentation for load, displacement, and velocity transducers should provide a sufficient number of ranges so that it will not be necessary to use < 20% of the range.

The load-frame carries the test fixture, test piece, sensors, and reinforces the test fixture, test piece and sensors against the test machine, so that the elastomeric part can be stressed by the test machine.

3.2.1.2 Measuring System. The measuring system mostly consists of converter systems for force and deflection, corresponding measuring amplifiers, downstream Analogue Digital (A/D) converters and the analysis processor. Error margins are specified in Table 1.

Table 1: Error Margins

Frequency	The Tolerated Error of the Frequency is ≤ ± 2% of the Measured Value	
Dynamic Stiffness	f ≤ 300 Hz	f > 300 Hz
	Tolerated error is ≤ ± 2% of the display values of the dynamic stiffness	Tolerated error is ≤ ± 5% of the display values of the dynamic stiffness
Loss Angle	f ≤ 300 Hz	f > 300 Hz
Loss Angle ≤ 20 degrees	Tolerated error is ≤ ± 0.2% of the display	Tolerated error is ≤ ± 5% of the display
Loss Angle > 20 degrees	Tolerated error is ≤ ± 1% of the display	

3.2.1.3 Analysis System. Analysis systems are used for the determination, storage and presentation of the measurements. The measurements may be evaluated by Fast Fourier Transform (FFT) using Fundamental Frequency, Sine Regression, or DIN 53513 analysis.

3.2.1.3.1 Sample Points. Digital analyzing methods can cause results to be affected by distortion of the oscillating force due to nonlinear spring characteristics. The number of sample points must be chosen such that the determination of the dynamic stiffness and the loss angle fulfils the required accuracy. There must be 100 to 200 sample points per wave.

3.2.1.3.2 Hysteresis Loop. Another source for error is caused by the rheology of the elastomer material. A displacement of the average value during the measurement may occur and the force-deflection-diagram must be adjusted. The analysis system must be capable of closing the hysteresis loop with a straight-line approximation.

3.2.1.3.3 Fixture Correction. The analysis system must allow a correction of the dynamic stiffness to account for the measured machine and fixture stiffness. Correction must be performed if the dynamic stiffness of the elastomeric part is ≥ 1% of the machine and fixture stiffness. If the dynamic stiffness of the elastomeric part is ≥ 10% of the machine and fixture stiffness, the result must be rejected.

3.2.2 Part Conditioning. For testing that requires controlled pre-conditioning and test temperatures, the capabilities in Table 2 are required.

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Table 2: Part Conditioning

Preconditioning-Chamber for Recirculating Air Operation	
Temperature range: (continuously controlled)	-50 °C to 250 °C
Temperature constancy:	≤ ± 2 °C
Temperature variation rate for the empty chamber:	≥ 1.5 °C/minute
Temperature-Variation-Chamber for Recirculating Air Operation for use with the Test Machine	
Temperature range: (continuously controlled)	-50 °C to 250 °C
Temperature constancy:	≤ ± 2 °C
Temperature variation rate for the empty chamber:	≥ 1.5 °C/minute

3.3 Test Vehicle/Test Piece. This procedure applies to all elastomer components including bushings, mounts, hangers and snubbers.

3.4 Test Time.

Calendar time: 2 d to 3 d

Test time: 4 h to 8 h

Coordination time: 1 h to 2 h

3.5 Test Required Information. Different information is required based on the purpose of the testing (e.g., for development or for validation). This information is generally specified in the appropriate statement of requirements (SOR) document. The following items are generally required.

3.5.1 Number of test pieces.

3.5.2 Required pre-conditioning temperature.

3.5.3 Required test temperature.

3.5.4 Direction of force application (in local coordinate system).

3.5.5 Static Force (Mean preload).

3.5.6 Dynamic Deflection: (millimeter, peak to peak).

3.5.7 Frequency: (frequency range, hertz).

3.5.8 Frequency Increment (hertz).

3.6 Personnel/Skills. Elastomer testing is quite complex. Several parameters must be adjusted and tracked for accurate results. It is highly recommended that a person with significant experience (more than 3 years) in elastomer testing perform the test.

3.7 Additional Information. For further background information with respect to the preparation and testing of Elastomeric Isolators, refer to SAE J1085, VDA 675480, and ISO 10846.

4 Procedure

4.1 Preparation. Test pieces shall be clean and free from debris. Virgin pieces must be allowed to age between manufacturing and testing for a minimum of 24 h. For initial approval and arbitration purposes, the minimum time period between vulcanization and testing shall be 7 days. For quality control purposes the minimum period shall be 72 h. Pieces that have undergone some permanent deformation (such as that due to an assembly operation) must be allowed 24 h before testing to permit relaxation of any internal stresses that may exist.

If the test piece is required to be pressed into a fixture, then a suitable lubricant shall be used and sufficient time allowed for the lubricant to have dried before commencing any tests.

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