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Testing Dynamic Properties of Elastomeric Isolators

RATIONALE

This technical report covers test methods which are mature and not likely to change in the foreseeable future.

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1. Scope—These methods cover testing procedures for defining and specifying the dynamic characteristics of simple elastomers and simple fabricated elastomeric isolators used in vehicle components. Simple, here, is defined as solid (non-hydraulic) components tested at frequencies less than or equal to 25 Hz.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein.

2.1.1 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 1349—Recommended Practice for Rubber—Standard Temperatures and Atmospheres for Testing and Conditioning

ASTM D 2231—Recommended Practice for Rubber Properties in Forced Vibration

ASTM D 2234—Method for Collection of a Gross Sample of Coal

ASTM E 177—Practice for Use of the Terms Precision and Bias in ASTM Test Methods

2.1.2 RAPRA PUBLICATIONS—Available from RAPRA Technology Ltd., Shawberry, Shrewsbury, Shropshire SY44NR, U.K.

D. Hands, "Simple Methods for Heat Flow Calculations," RAPRA Technical Review No. 60, Class No. 96, July 1971

Marion D. Thompson, "Cooling Rubber Slabs," RAPRA Bulletin, May 1972

2.1.3 OTHER PUBLICATIONS

S. D. Gehman, "Heat Transfer in Processing and Use of Rubber," Rubber Chem. & Tech., 1967, pp. 36–99

2.2 Related Publications—The following publications are provided for information purposes only and are not a required part of this document.

2.2.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE SP-375, ASTM STP-535—The Measurement of the Dynamic Properties of Elastomers and Elastomeric Mounts, B. M. Hillberry and A. F. Hegerich, Proceedings of Symposium presented at SAE International Automotive Engineering Congress, Detroit, January 1973

2.2.2 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 832—Recommended Practice for Rubber Conditioning for Low Temperature Testing

ASTM D 1053—Test for Rubber Property—Stiffening at Low Temperature Testing

ASTM D 1229—Test for Rubber Property—Compression Set at low Temperature

ASTM D 1329—Test for Rubber Property—Retraction at Low Temperatures (TR Test)

ASTM D 1566—Definition of Terms Relating to Rubber

ASTM E 4—Verification of Testing Machines

ASTM E 74—Calibration of Force-Measuring Instruments for Verifying the Load Indication of Testing Machines

3. Summary—These methods describe procedures for measuring the dynamic characteristics of automotive elastomeric mountings using forced vibration testing machines. These characteristics are the elastic spring rate, damping coefficient, and loss tangent. Either fabricated mountings or elastomer specimens may be tested. Since measured dynamic properties are highly dependent upon test conditions, emphasis has been placed on the definition of suitable conditions.

4. Description of Terms—These terms are in common use throughout the North American automotive industry. Alternate Terminology has been added to assist in cross-referencing terminology from other areas of the world. Please use SAE terminology to avoid confusion and data inaccuracies.

4.1 Test Temperature

4.1.1 AMBIENT TEMPERATURE—The temperature of the environment surrounding the test specimen. Unless otherwise specified, it is assumed that the sample is at the ambient temperature before being subjected to dynamic flexing.

4.1.2 PART TEMPERATURE—The temperature obtained by locating a temperature-sensing device in or on the specimen. In most cases, temperature gradients that develop within flexing rubber specimens make it necessary to define the precise points and techniques used to measure temperature.

4.2 Frequency (f)—The number of complete cycles, whole periods, of forced vibrations per unit of time caused and maintained by a periodic excitation, usually sinusoidal.

4.3 Preload—An external static load producing a strain in a test specimen. Preload is imposed prior to forced vibration testing. Preload is usually expressed in Newtons (pounds) of force instead of meters (inches) of deflection.

4.4 Double Amplitude (DA)—The peak-to-peak amplitude as applied to the elastomer specimen measured in the direction of the applied vibration. Two times the single peak value in either the plus or minus direction may not be equivalent to the peak-to-peak value.

4.5 Complex Spring Rate (K^*)—The effective spring rate of a part under sinusoidal dynamic stress. It is the peak-to-peak force across the sample divided by the peak-to-peak displacement. The complex spring rate can be visualized as being the vector sum of an elastic component and a viscous damping component.

4.5.1 ALTERNATE TERMINOLOGY

- a. Complex Stiffness
- b. K-dynamic (K_d , K_{dyn})
- c. Dynamic Stiffness (sometimes confused with 4.6)

4.6 Dynamic Spring Rate (K)—The proportionality factor between the component of the applied force vector that is in phase with the displacement and the displacement vector. The dynamic spring rate is equal to the elastic component of the complex spring rate.

4.6.1 ALTERNATE TERMINOLOGY

- a. Elastic Spring Rate (K_{el})
- b. Dynamic Stiffness (K')
- c. Storage Stiffness (K'')

4.7 Damping Coefficient (C)—The proportionality factor between the component of the applied force vector which is in phase with velocity and the velocity vector.

4.8 Loss Rate (Cw)—The proportionality factor between the magnitude of the component of the applied force vector that is in phase with the velocity and the magnitude of the displacement vector, where:

$$\omega = 2\pi f \quad (\text{Eq. 1})$$

NOTE—The magnitudes of the complex spring rate, elastic spring rate, and loss rate are related by Equation 2:

$$K^* = \text{complex spring rate} \quad (\text{Eq. 2})$$

$$K^* = \sqrt{(K')^2 + (C\omega)^2} \quad (\text{Eq. 3})$$

Equation 3 is sometimes written as shown in Equation 4:

$$(K^*)^2 = (K')^2 + (K'')^2 \quad (\text{Eq. 4})$$

where

$$K'' = C \omega$$

4.8.1 ALTERNATE TERMINOLOGY

- a. Loss Stiffness (K'')
- b. Viscous Stiffness (K'')

4.9 Loss Tangent ($\tan \delta$)—The tangent of the phase angle between the applied force and the resulting displacement:

$$\tan \delta = \frac{C\omega}{K} \quad (\text{Eq. 5})$$

4.9.1 ALTERNATE TERMINOLOGY

- a. Loss factor

5. General Testing Methods

5.1 Preparation Prior To Testing

- 5.1.1 Virgin specimens must be allowed to age between manufacturing and testing. Typically, a minimum of 24 h is suggested. Elastomeric specimens that have undergone some permanent deformation (such as that due to an assembly operation) may require additional time to permit relaxation of any internal stresses that may exist.
- 5.1.2 Parts that have been kept at temperatures other than the test temperature (for example, during shipment, storage, or environmental testing) must be conditioned at the test temperature long enough to achieve uniform temperature stabilization throughout. Minimum conditioning time depends upon many factors, including temperature difference, specimen size and shape, and airflow around the specimen. Guidance for determining the required conditioning time is given in Appendix A.
- 5.1.3 All test equipment instrumentation should be fully stabilized per manufacturer's instructions. At least 1/2 h is required. Greater stability is obtained by leaving electronic equipment on permanently. It is recommended that at the start and conclusion of every test session or operator change, a quick check of calibration be performed with a control specimen.

5.2 Outline Of Test Procedure

- 5.2.1 Insert the specimen.
- 5.2.2 Apply the preload.
- 5.2.3 Apply and maintain the dynamic conditions of test.
- 5.2.4 Stabilize specimen properties.
- 5.2.5 Read data within 1 min.
- 5.2.6 Remove the specimen if no further measurements are to be made.

5.3 Preferred Test Conditions

- 5.3.1 Where a single measurement is to be made on a specimen, the following reference test conditions are suggested in the interests of standardization. They take into account: the precision of equipment, stabilization of specimen dynamic properties, minimization of heat buildup, avoidance of regions in which elastomers are most sensitive to changes in test conditions, and relevance to most practical applications.
 - 5.3.1.1 *Preload*—Selected to correspond to that existing in the intended application. Sufficient preload should be applied to prevent any separation of sample-to-machine interfaces unless all interfaces are securely attached. The preload should be chosen so that any sharp changes in the slope of the load-deflection curve are avoided.
 - 5.3.1.2 *Double Amplitude*—0.50 mm (0.020 in).
 - 5.3.1.3 *Frequency*—15 Hz.