

Test for Dynamic Properties of Elastomeric Isolators—SAE J1085a

SAE Recommended Practice
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TEST FOR DYNAMIC PROPERTIES OF ELASTOMERIC ISOLATORS—SAE J1085a

SAE Recommended Practice

Report of Nonmetallic Materials Committee approved September 1974 and last revised August 1978.

1. Scope—These methods cover testing procedures for defining and specifying the dynamic characteristics of elastomers and fabricated elastomeric isolators used in vehicle components.

2. 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.

3. Description of Terms—These terms are in common use throughout the automotive industry:

3.1 Test Temperature

3.1.1 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.

3.1.2 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.

3.2 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.

3.3 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 metres (inches) of deflection.

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

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

3.6 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.

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

3.8 Loss Rate ($C\omega$)—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:

$$\omega = 2\pi f$$

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

$$K^* = \text{complex spring rate} \\ |K^*| = \sqrt{(K')^2 + (C\omega)^2}$$

The last equation is sometimes written:

$$(K^*)^2 = (K')^2 + (K'')^2$$

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

$$\tan \delta = \frac{C\omega}{K}$$

4. General Testing Methods

4.1 Outline of Procedure

4.1.1 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.

4.1.2 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 the Appendix.

4.1.3 All test equipment instrumentation should be fully stabilized per manufacturer's instructions. At least $\frac{1}{2}$ 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.

4.1.4 Insert the specimen.

4.1.5 Apply the preload.

4.1.6 Apply and maintain the dynamic conditions of test for 5 min.

4.1.7 Data should then be recorded within 1 min.

4.1.8 Remove the specimen if no further measurements are to be made.

4.2 Preferred Test Conditions

4.2.1 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 requirements of precision of equipment, minimization of heat buildup, avoidance of regions in which elastomers are most sensitive to changes in test conditions, and relevance to most practical applications.

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.

DOUBLE AMPLITUDE—0.50 mm (0.020 in).

FREQUENCY—15 Hz.

AMBIENT TEMPERATURE— $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$).

4.2.2 Additional or alternate test conditions should follow the guidelines in ASTM D 2231, Recommended Practice for Forced Vibration Testing of Vulcanizates, and ASTM D 1349, Recommended Practice for Standard Test Temperatures for Rubber and Rubber-like Materials. The following ambient temperatures are suggested for testing elastomers used in automotive applications:

$^\circ\text{C}$	$^\circ\text{F}$
-40	-40
-10	+14
+23	+73.4
+100	+212
+150	+302

4.2.3 Alternative Cold Test Procedure

4.2.3.1 Discussion—When a specimen has been temperature stabilized at a test temperature such as -40°C (-40°F), any test data obtained in the first few thousand cycles will be transient data. Each unit of energy input will change the specimen's dynamic properties. The following procedure is suggested so data can be obtained in a repeatable manner when specimen response is changing.

4.2.3.2 Pre Test Preparation

4.2.3.2.1 Prepare the test machine to record test data continuously during test so that information pertaining to any particular cycle can be determined.

Include the following:

1. Test cycles count.

2. Dynamic spring rate.

3. Damping coefficient.

4. Test chamber ambient temperature—Temperature sensor will be located to best sense the temperature of the test chamber ambient to which the sample is subjected.

5. Energy input ($\int_0^t F(t)V(t)dt$).

6. Specimen temperature—Is assumed the same as chamber ambient when correctly stabilized at start of test.

4.2.3.2.2 Prior to Test—Weigh the specimen (include all specimen elements that are molded together or fastened together).

4.2.3.2.3 Insert the specimen.

4.2.3.2.4 Condition the specimen at test temperature.

4.2.3.2.5 Preload—There are two ways to soak the specimen at ambient temperature with or without preload. Measured dynamic characteristics are influenced by preload history. The desired condition should be specified in

test requests.

Ø 4.2.3.2.5.1 *Soak Period with Preload*—The preload will be maintained until the entire soak period and test is complete.

Start of Preload:

Load Control—No stabilization required.

Displacement Control—Preload stabilization period will be required.

Ø 4.2.3.2.5.2 *Soak Period without Preload*—The preload is added following the soak period and maintained until the test is complete.

Ø 4.2.3.3 *Test Machine Control During Test*—Equipment used to perform extended environmental tests should have the required capability. When equipment does not have the required capability this method makes no suggested compromises. Machine control must be directed at measuring transient response and obtaining repeatable data.

Ø 4.2.3.4 *Data Reduction*—Should include the following information pertaining to the cycle of interest:

Ø 4.2.3.4.1 Number of cycles.

Ø 4.2.3.4.2 Spring rate.

Ø 4.2.3.4.3 Damping coefficient.

Ø 4.2.3.4.4 Total energy input.

Ø 4.2.3.4.5 Total energy input per unit weight of specimen. When reading the dynamic spring rate or damping, use the average for the specified cycle such as; cycle 100 equals the end of 99 to the beginning of 101.

4.3 Specimens

4.3.1 Standard compression specimens used for comparing elastomer properties or standardizing test machines should be chosen based on the following considerations:

4.3.1.1 The size of the specimens shall be chosen to suit the load capacities of the test machine but should be no less than 12.7 mm (0.50 in) nor more than 50.8 mm (2.0 in) high; the recommended height is 25.4 mm (1.0 in).

4.3.1.2 The preferred shape factor for comparing elastomer properties is 0.5 where:

$$\text{Shape factor} = \frac{\text{area of one loaded face}}{\text{area free to bulge}}$$

4.3.1.3 The preferred shape is a right circular cylinder with faces parallel within 0.001 mm/mm or 0.001 in./in.

4.3.1.4 *Test Interface*—For best reproducibility, the sample mentioned in paragraph 4.3.1.2 should have metal plates bonded to both faces during vulcanization.

4.3.1.5 *Optional Test Interface*—The test machine will be equipped with loading plates top and bottom of sufficient area to support the loaded specimen. The specimen will be held in place with 300 grit sandpaper, securely bonded to both loading plates. The sandpaper prevents specimen lateral movement and aids in bulge control. The two plates exciting the specimen shall be parallel within 0.001 mm/mm (0.001 in./in.) of platen length in the neutral position. Plate parallelism will be within tolerances on orthogonal lines.

4.3.2 Standard shear specimens shall comply with ASTM D 2231 for general configuration. Dimensions may be adjusted to provide required spring rates. Supporting fixtures should be sufficiently rigid to maintain parallelism of all plates.

4.3.3 The following considerations shall apply when fabricated mountings or bushings are tested:

4.3.3.1 Supporting fixtures shall be designed to restrain lateral movement of the top or bottom surfaces of the mounting as a result of forces applied in the test direction.

4.3.3.2 It shall be carefully determined that any lateral forces which may develop as a result of forces applied in the test direction do not influence the test readings.

NOTE—A correction factor will be required unless the overall spring rate of the fixtures and the machine elements that are included in the measurement is sufficiently high. With an infinitely rigid specimen installed, the machine and fixture spring rate should be at least 100 times greater than the nominal spring rate of the test specimen. If this degree of rigidity cannot be achieved, the correction factor shall be calculated and applied.

4.3.4 Standard specimens to be tested must be clearly marked for identification.

4.3.5 Standard specimens used for standardizing test machines shall be aged no less than one month and shall be accepted only after repetitive testing indicates that dynamic properties have stabilized.

4.4 Specific Procedures

4.4.1 **FORCED NONRESONANT SYSTEMS**—A forced nonresonant system is comprised of a drive mechanism which forces the specimen through a desired sinusoidal load, displacement, or energy. The desired frequency and amplitude of the test are not affected by the specimen's dynamic response; therefore, test conditions may be quite easily changed.

4.4.1.1 *Theory*—In a forced nonresonant system, the sample is excited

with a sinusoidal oscillation which is either force or displacement controlled. The forcing medium causing this sinusoidal oscillation can be an electro-mechanical, electrohydraulic system, or a pure mechanical system.

This method assumes that the existing force or displacement and the response of the specimen can be considered to be sinusoidal. If this is not the case, special methods of analysis are required.

The transmitted force is measured by a load cell in contact with the sample, preferably on the stationary side to minimize errors due to acceleration of the mass of the fixture. The component of this force which is in phase with velocity and the component that is in phase with the displacement are usually determined electronically. From this information, the values of C and K are usually determined. The vector phase relationships are illustrated in Fig. 1.

4.4.1.2 *Apparatus*—The basic elements of a forced nonresonant system are the drive system, the control system, a loading frame, transducers, and the instrumentation for readout.

4.4.1.2.1 *Drive System*—The system should be capable of providing sinusoidal dynamic operation, with minimum harmonic distortion, in the same direction as the applied force.

4.4.1.2.2 *Control*—A means of precise control over the input drive unit is required for repeatable test results. Controls for mean input, dynamic input, and frequency should be independently selectable for the desired test condition.

4.4.1.2.3 *Transducers and Instrumentation*—Common transducer signals used in forced nonresonant systems for obtaining data are load, displacement, and/or velocity. Each transducer should be calibrated to the following minimum accuracies.

Load: $\pm 0.5\%$ of full-scale for each calibrated range.

Displacement: $\pm 0.5\%$ of full-scale for each calibrated range.

Velocity: $\pm 1.0\%$ 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 outputs less than 20% of range. Scales in the ratio of 1, 2, 5, 10 are suggested.

Precautions listed in ASTM D 2231, paragraph 4.2 should be observed in selecting transducers, electronics, and techniques of calibration.

4.4.1.2.4 *Preferred Location of Transducers*—The load cell shall be mounted on the stationary side of the sample being tested.

The displacement and/or velocity transducer should be located directly across the sample and should not include a compliant structure within its measurement path. It should be located parallel to and as close as possible to the centerline of the exciting force.

4.4.1.2.5 *Fixture Mass*—The mass of the fixture located on the stationary platen shall be minimized to reduce errors due to mass-inertia accelerations. The fixture located on the moving platen shall be rigid to eliminate any possibility of structural resonances near operating frequencies.

5. *Report*—The report shall include the following:

5.1 Type of testing machine used.

5.1.1 Test specimen(s) identification.

5.1.2 Type of specimen loading, for example, compression or shear. For specimens of complex configuration, full description of fixtures used, with diagrams if necessary.

5.1.3 Date of test.

5.1.4 Preload.

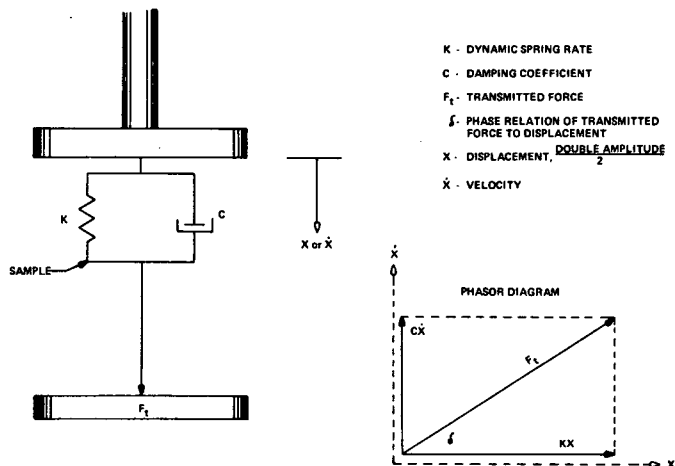


FIG. 1