



Designation: D 2231 – 94

AMERICAN SOCIETY FOR TESTING AND MATERIALS

1916 Race St. Philadelphia, Pa 19103

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Standard Practice for Rubber Properties in Forced Vibration¹

This standard is issued under the fixed designation D 2231; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes the terms used in the field of dynamic mechanical testing, the factors involved in forced vibration testing of vulcanizates, and recommends standard test conditions.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- D 945 Test Methods for Rubber Properties in Compression or Shear (Mechanical Oscillograph)²
- D 1054 Test Method for Rubber Property—Resilience Using a Rebound Pendulum²
- D 1349 Practice for Rubber—Standard Temperatures for Testing²

3. Terminology

3.1 Descriptions of Terms Specific to This Standard:

3.1.1 Each of the following terms and relationships apply to linear lumped models of rubber behavior.

3.1.2 It is recommended that the unqualified term “modulus” should mean “shear modulus.” “Normal” or “extension” or “Young’s” modulus should be so prefaced. “Bulk” or “hydrostatic compression” modulus of elastomers is an order of magnitude larger than the deformation moduli considered here.

3.1.3 *Terms Applying to Any Periodic Motion of Mechanical Systems:*

3.1.3.1 *energy loss*—the energy per unit volume that is lost in each deformation cycle. It is the ratio of the energy represented by hysteresis loop area to the test specimen volume.

3.1.3.2 *mean modulus*—the ratio of mean stress to mean strain.

3.1.3.3 *mean stress*—the stress at the axis of symmetry of the stress-strain cycle or, if asymmetrical, a value halfway between maximum and minimum stress.

3.1.3.4 *mechanical hysteresis loop*—the closed curve defined by the locus of successive stress-strain values of a test specimen during a cyclic deformation.

3.1.3.5 *power loss*—the power per unit volume that is transformed into heat through hysteresis, it is the product of energy loss and frequency.

3.1.4 *Terms Applying to Sinusoidal Motion:*

3.1.4.1 *absolute value of complex modulus (Mod G^* , $|G^*|$)*—the magnitude of the complex modulus, $|G^*| = \sqrt{G'^2 + G''^2}$.

3.1.4.2 *complex modulus, G^** —the resultant shear stress divided by the resultant shear strain where each is a vector which may be represented by a complex number, $G^* = G' + iG''$.

3.1.4.3 *damping constant, c* —the component of applied force that is 90° out of phase with the deformation, divided by the velocity of deformation.

3.1.4.4 *loss angle, δ* —the phase angle between stress and strain.

3.1.4.5 *loss factor (loss tangent, $\tan \delta$, $\tan \delta$, $\tan \delta$)*—the ratio between loss modulus and storage modulus. Loss factor = $\tan \delta$. $\tan \delta = G''/G'$.

3.1.4.6 *loss modulus (viscous modulus, hysteretic modulus, imaginary modulus, out-of-phase modulus), G''* —the component of applied shear stress that is 90° out of phase with the shear strain, divided by the strain.

3.1.4.7 *normal loss modulus, E''* —the component of applied normal stress that is 90° out of phase with the normal strain, divided by the strain.

3.1.4.8 *normal storage modulus, E'* —the component of applied normal stress that is in phase with the normal strain, divided by the strain.

3.1.4.9 *pure sinusoidal motion*—motion which follows the mathematical equation $x = X_o \sin(2\pi ft)$ where X_o is the single amplitude of motion, f is the frequency in Hz, and t is time in seconds.

3.1.4.10 *root mean square strain*—the strain amplitude divided by $\sqrt{2}$.

3.1.4.11 *root mean square stress*—the stress amplitude divided by $\sqrt{2}$.

3.1.4.12 *spring constant, k* —the component of applied force in phase with displacement divided by the displacement amplitude (zero to peak on one side only).

3.1.4.13 *storage modulus (elastic modulus, real modulus,*

¹ This practice is under the jurisdiction of ASTM Committee D-11 on Rubber and is the direct responsibility of Subcommittee D11.14 on Time and Temperature-Dependent Physical Properties.

Current edition approved Feb. 15, 1994. Published May 1994. Originally published as D 2231 – 63 T. Last previous edition D 2231 – 87.

² Annual Book of ASTM Standards, Vol 09.01.