



Standard Test Method for Rubber Compounds—Measurement of Unvulcanized Dynamic Strain Softening (Payne Effect) Using Sealed Cavity Rotorless Shear Rheometers¹

This standard is issued under the fixed designation D8059; 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 test method covers the use of a sealed cavity rotorless oscillating shear rheometer for the measurement of the softening effects of rising sinusoidal strain when applied to an unvulcanized rubber compound containing significant amounts of colloidal fillers (such as silica or carbon black, or both) from a rubber mixing procedure. These strain softening properties relate to mixing conditions, the composition of the rubber compound, colloidal particle (Payne Effect) characteristics of the fillers, and in some cases the degree of reaction between an organosilane and precipitated, hydrated silica during mixing. This procedure is being commonly applied to rubber reactive mixing procedures.

1.2 *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:*²

D1566 Terminology Relating to Rubber

3. Terminology

3.1 *Definitions:*

3.1.1 *elastic torque, S' , n* —the peak amplitude torque component which is in phase with a sinusoidally applied strain.

3.1.2 *viscous torque, S'' , n* —the peak amplitude torque component which is 90° out of phase with a sinusoidally applied strain.

3.1.3 *complex torque, S^* , n* —the peak amplitude torque response measured by a reaction torque transducer for a sinusoidally applied strain; mathematically, S^* is computed by $S^* = (S'^2 + S''^2)^{1/2}$.

3.1.4 *loss angle, δ , n* —the phase angle by which the complex torque (S^*) leads a sinusoidally applied strain.

3.1.5 *storage shear modulus, G' , n* —the ratio of (elastic) peak amplitude shear stress to peak amplitude shear strain for the torque component in phase with a sinusoidally applied strain; mathematically, $G' = [(S'/\text{Area})/\text{Peak Strain}]$.

3.1.6 *loss shear modulus, G'' , n* —the ratio of (viscous) peak amplitude shear stress to peak amplitude shear strain for the torque component 90° out of phase with a sinusoidally applied strain; mathematically, $G'' = [(S''/\text{Area})/\text{Peak Strain}]$.

3.1.7 *complex shear modulus, G^* , n* —the ratio of peak amplitude shear stress to peak amplitude shear strain; mathematically, $G^* = [(S^*/\text{Area})/\text{Strain}] = (G'^2 + G''^2)^{1/2}$.

3.1.8 *loss factor, $\tan \delta$, n* —the ratio of loss modulus to storage modulus, or the ratio of viscous torque to elastic torque; mathematically, $\tan \delta = G''/G' = S''/S'$.

3.1.9 *Payne Effect, n* —in the low amplitude dynamic testing of filled rubbers, the decrease in modulus (G' or E') as the amplitude of deformation is increased.

3.1.9.1 *Discussion*—The effect is caused by a decrease in the additive contributions of polymer-polymer interactions, hydrodynamic effects, the polymer-filler and filler-filler interactions.

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4. Summary of Test Method

4.1 An uncured rubber compound specimen is contained in a sealed die cavity which is closed and maintained at an elevated temperature. The cavity is formed by two dies, one of which is oscillated through a rotary amplitude. This action produces a sinusoidal torsional strain in the test specimen resulting in a sinusoidal torque, which measures a viscoelastic quality of the test specimen. The test specimen can be an uncured rubber compound containing carbon black, precipitated hydrated silica, or both of these reinforcing fillers. The silica loaded compounds may also contain an organosilane

¹ This test method is under the jurisdiction of ASTM Committee D11 on Rubber and Rubber-like Materials and is the direct responsibility of Subcommittee D11.12 on Processability Tests.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.