



Designation: D 5099 – 93 (Reapproved 1998)

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
Reprinted from the Annual Book of ASTM Standards. Copyright ASTM

Standard Test Methods for Rubber—Measurement of Processing Properties Using Capillary Rheometry¹

This standard is issued under the fixed designation D 5099; 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 These test methods describe how capillary rheometry may be used to measure the rheological characteristics of rubber (raw or compounded). Two methods are addressed: Method A—using a piston type capillary rheometer, and Method B—using a screw extrusion type capillary rheometer. The two methods have important differences, as outlined in 7-10 and 11-14, respectively.

1.2 These test methods cover the use of a capillary rheometer for the measurement of the flow properties of thermoplastic elastomers, unvulcanized rubber, and rubber compounds. These material properties are related to factory processing.

1.3 Since piston type capillary rheometers impart only a small amount of shearing energy to the sample, these measurements directly relate to the state of the compound at the time of sampling. Piston capillary rheometer measurements will usually differ from measurements with a screw extrusion type rheometer, which imparts shearing energy just before the rheological measurement.

1.4 Capillary rheometer measurements for plastics are described in Test Method D 3835.

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

1.6 *This standard does not purport to address all of the safety problems, 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 1349 Practice for Rubber—Standard Temperatures for Testing²

D 1485 Test Methods for Rubber from Natural Sources—Sampling and Sample Preparation²

D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets²

D 3835 Test Method for Determination of Properties of Polymeric Materials by Means of a Capillary Rheometer³

D 3896 Practice for Rubber from Synthetic Sources—Sampling²

D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries²

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *apparent (uncorrected) shear rate* (γ)—shear strain rate (or velocity gradient) of the rubber extrudate as it passes through the capillary die.

3.1.1.1 *Discussion*—This velocity gradient is not uniform through the cross-section of the capillary die. The shear rate is calculated for the region of highest shear, at the wall of the capillary. By selecting a die diameter and controlling the volume flow per unit time through the die, a specific level of apparent shear rate may be achieved. Alternately, the shear stress (entrance pressure) may be controlled, and the apparent shear rate measured.

3.1.1.2 Mathematically, the apparent shear rate for a Newtonian fluid at the wall is given as follows:

$$\gamma = \frac{32 Q}{\pi D^3} \quad (1)$$

where:

γ = apparent shear rate,

Q = quantity of fluid extruded in one second, mm³,

π = the constant pi, approximately 3.142, and

D = diameter of the measuring capillary, mm.

The units of apparent shear rate are reciprocal seconds (s⁻¹).

3.1.2 *apparent shear stress* (τ)—the measured resistance to flow through a capillary die; it may be determined by measuring the die entrance pressure for a specified die, then applying appropriate geometric factors.

3.1.2.1 Mathematically, apparent shear stress is given as follows:

$$\tau = \frac{P}{4(L/D)} \quad (2)$$

where:

¹ These test methods are under the jurisdiction of ASTM Committee D-11 on Rubber and are the direct responsibility of Subcommittee D11.12 on Processability Tests.

Current edition approved Feb. 15, 1993. Published May 1993.

² *Annual Book of ASTM Standards*, Vol 09.01.

³ *Annual Book of ASTM Standards*, Vol 08.02.