Designation: D7175 – 23

Standard Test Method for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer[1]

This standard is issued under the fixed designation D7175; 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 determination of the complex shear modulus and phase angle of asphalt binders when tested in dynamic (oscillatory) shear using parallel plate geometry.

1.2 This test method is intended for determining the linear viscoelastic properties of asphalt binders as required for specification testing and is not intended as a comprehensive procedure for the full characterization of the viscoelastic properties of asphalt binder.

1.3 This standard is appropriate for unaged asphalt binder, conditioned asphalt binder, and asphalt binder recovered from either asphalt mixtures or asphalt emulsions. To keep the language in this standard precise, the term "asphalt binder" is used to refer to the material being tested.

1.4 This procedure is limited to asphalt binders that contain particles with largest dimension less than 250 µm.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 **Warning—**Mercury has been designated by the United States Environmental Protection Agency (EPA) and many state agencies as a hazardous material that can cause central nervous system, kidney, and liver damage. Mercury, or its vapor, may be hazardous to health and corrosive to materials. Caution should be taken when handling mercury and mercury-containing products. See the applicable product Safety Data Sheet (SDS) for details and EPA's website— www.epa.gov/mercury/faq.htm—for additional information. Users should be aware that selling mercury, mercury-containing products, or both, into your state may be prohibited by state law.

1.7 *This standard may involve hazardous materials, operations, and equipment. 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

D8 Terminology Relating to Materials for Roads and Pavements

D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials

D6373 Specification for Performance-Graded Asphalt Binder

D8239 Specification for Performance-Graded Asphalt Binder Using the Multiple Stress Creep and Recovery (MSCR) Test

E1 Specification for ASTM Liquid-in-Glass Thermometers

E77 Test Method for Inspection and Verification of Thermometers

E644 Test Methods for Testing Industrial Resistance Thermometers

E882 Guide for Accountability and Quality Control in the Chemical Analysis Laboratory

2.2 *AASHTO Standards:*[3]

R 29 Practice for Grading or Verifying the Performance Grade of an Asphalt Binder

[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.44 on Rheological 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.

[3] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

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2.3 *ISO Standard:*[4]

ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories

3. Terminology

3.1 *Definitions*—Definitions for many terms common to asphalt binder are found in Terminology D8.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *annealing, n*—the process of removing the effects of steric hardening by heating the binder until it is sufficiently fluid so that it can be easily poured.

3.2.2 *complex shear modulus (G*), n*—ratio calculated by dividing the absolute value of the peak-to-peak shear stress, τ, by the absolute value of the peak-to-peak shear strain, γ.

3.2.3 *linear viscoelastic, adj—within context of this test method*, refers to a region of behavior in which the complex shear modulus is independent of the amplitude of the shear stress or strain.

3.2.4 *oscillatory shear, n*—refers to a type of loading in which a shear stress or shear strain is applied to a test sample in an oscillatory manner such that the shear stress or strain varies in amplitude about zero in a sinusoidal manner.

3.2.5 *parallel plate geometry, n*—refers to a testing geometry in which the test specimen is sandwiched between two rigid parallel plates.

3.2.6 *phase angle (δ), n*—the angle in degrees between the peak of a sinusoidally applied strain and the resultant peak of respective sinusoidal stress.

3.2.7 *portable thermometer, n*—refers to an electronic device that is separate from the dynamic shear rheometer and that consists of a detector (probe containing a thermocouple or resistive element), associated electronic circuitry, and readout system.

3.2.8 *reference thermometer, n*—refers to a liquid-in-glass or electronic thermometer that is used as a laboratory reference standard and is calibrated by an agency accredited to ISO/IEC 17025.

3.2.9 *steric hardening, n*—a process where molecular associations occur between asphalt binder molecules during storage at ambient temperature.

3.2.9.1 *Discussion*—Steric hardening decreases the phase angle and increases the complex shear modulus. Steric hardening is time and temperature dependent and is asphalt binder specific. It may significantly affect the test results after just a few hours of storage at ambient temperature.

3.2.10 *strain sweep*—an isothermal test procedure in which the strain is increased stepwise at a linear rate of increase.

3.2.11 *thermal equilibrium, n*—condition where the temperature of the test specimen mounted between the test plates is constant with time.

4. Summary of Test Method

4.1 Test specimens are formed between parallel metal plates and one of the parallel plates is oscillated with respect to the other at pre-selected temperatures, frequencies, and rotational strain amplitudes. The required amplitudes are specified to ensure that the measurements are within the region of linear behavior.

4.2 The test specimen is maintained at the test temperature by positive heating and cooling of the upper and lower plates or by enclosing the upper and lower plates in a thermally controlled environment or test chamber.

4.3 Specification testing is performed at a test frequency of 10 rad/s. The complex modulus (G*) and phase angle (δ) are calculated automatically as part of the operation of the rheometer using proprietary computer software supplied by the instrument manufacturer.

5. Significance and Use

5.1 The complex shear modulus is an indicator of the stiffness or resistance of asphalt binder to deformation under load. The phase angle is a measure of the relative portion of the response to an applied load that is elastic (recoverable) or viscous (nonrecoverable).

5.2 The test procedure is applicable to measurements in the linear region where the measured modulus and phase angle are independent of the amplitude of the strain.

5.3 The complex modulus and the phase angle are used to calculate performance-related criteria in accordance with Specification D6373 or D8239.

NOTE 1—The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of Specification D3666 are generally considered capable of competent and objective testing, sampling, inspection, etc. Users of this standard are cautioned that compliance with Specification D3666 alone does not completely ensure reliable results. Reliable results depend on many factors; following the suggestions of Specification D3666 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.

6. Apparatus

6.1 *Dynamic Shear Rheometer (DSR) Test System*—A dynamic shear rheometer test system consisting of test plates, an environmental chamber, an internal thermometer, a loading device, and a data acquisition system as described in 6.1.1 – 6.1.5. The manufacturer of the device shall provide a certificate certifying that the frequency, deflection angle, and torque are controlled and measured with an accuracy of 1 % or less in the range of this measurement.

6.1.1 *Test Plates*—Metal plates cylindrical in shape, formed from steel or aluminum, with smooth ground surfaces are required. Specification testing to D6373 or D8239 requires two plates (upper and lower) 8.00 ± 0.02 mm in diameter and two plates (upper and lower) 25.00 ± 0.05 mm in diameter (Item A

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.