Designation: D2171/D2171M – 22

Standard Test Method for Viscosity of Asphalts by Vacuum Capillary Viscometer[1]

This standard is issued under the fixed designation D2171/D2171M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.
This test method has been approved by the sponsoring committees and accepted by the cooperating societies in accordance with established procedures.

1. Scope

1.1 This test method covers procedures for the determination of the apparent viscosity of asphalt binder by vacuum capillary viscometers at 60 °C [140 °F]. It is applicable to materials having viscosities in the range from 0.0036 to over 20 000 Pa·s [0.036 to over 200 000 P].

NOTE 1—This test method is suitable for use at other temperatures, but the precision is based on determinations on asphalt binders at 60 °C [140 °F].

NOTE 2—Modified asphalt binders or asphalt binders that have been conditioned or recovered are typically non-Newtonian under the conditions of this test. The apparent viscosity for non-Newtonian asphalt binders varies with shear rate. When the flow is non-Newtonian in a capillary tube, the shear rate determined using this test method may be invalid. The presence of non-Newtonian behavior for the test conditions of this test can be verified by measuring the viscosity with viscometers having different-sized capillary tubes or with different pressure heads. The defined precision limits in Section 11 may not be applicable to non-Newtonian asphalt binders. Test Method D4957 may be a more applicable method for testing non-Newtonian asphalts.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.3 **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 Material Safety Data Sheet (MSDS) or Safety Data Sheet (SDS) for details and the EPA's website—http://www.epa.gov/mercury/faq.htm—for additional information. Users should be aware that selling mercury, mercury-containing products, or both, in your state may be prohibited by state law.

1.4 The text of this standard references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.5 *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.*

1.6 *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
D4957 Test Method for Apparent Viscosity of Asphalt Emulsion Residues and Non-Newtonian Asphalts by Vacuum Capillary Viscometer
E1 Specification for ASTM Liquid-in-Glass Thermometers
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
E77 Test Method for Inspection and Verification of Thermometers
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

[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.

E879 Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements
E1137/E1137M Specification for Industrial Platinum Resistance Thermometers

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *Newtonian viscosity, n*—the viscosity of a liquid that is shear-rate independent, in which the rate of shear is linearly proportional to the shearing stress.

3.1.2 *non-Newtonian viscosity, n*—the viscosity of a liquid that is shear-rate dependent, in which the rate of shear is not linearly proportional to the shearing stress.

3.1.3 *viscosity (coefficient of), n*—the ratio between the applied shear stress and rate of shear is called the coefficient of viscosity.

3.1.3.1 *Discussion*—This coefficient is a measure of the resistance to flow of the liquid. It is commonly called the viscosity of the liquid. The cgs unit of viscosity is 1 g/cm·s (1 dyne·s/cm^2) and is called a poise (P). The SI unit of viscosity is 1 Pa·s (1 N·s/m^2) and is called a Pascal-second. One Pa·s is equivalent to 10 P.

3.2 For definitions of other terms used in this standard, refer to Terminology D8.

4. Summary of Test Method

4.1 The time is measured for a fixed volume of the liquid to be drawn up through a capillary tube by means of vacuum, under closely controlled conditions of vacuum and temperature. The viscosity in Pascal-seconds is calculated by multiplying the flow time in seconds by the viscometer calibration factor.

5. Significance and Use

5.1 The viscosity at 60 °C [140 °F] characterizes flow behavior and may be used for specification requirements for cutback asphalt and asphalt binders.

NOTE 3—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 *Viscometers,* capillary-type, made of borosilicate glass, annealed, suitable for this test are as follows:

6.1.1 *Cannon-Manning Vacuum Viscometer* (CMVV), as described in Appendix X1.

6.1.2 *Asphalt Institute Vacuum Viscometer* (AIVV), as described in Appendix X2.

6.1.3 *Modified Koppers Vacuum Viscometer* (MKVV), as described in Appendix X3.

6.1.4 Calibrated viscometers are available from commercial suppliers. Details regarding calibration of viscometers are given in Appendix X4.

NOTE 4—The viscosity measured in a CMVV may be from 1 to 5 % lower than either the AIVV or MKVV having the same viscosity range. This difference, when encountered, may be the result of non-Newtonian flow.[3]

6.2 *Thermometers*—A calibrated thermometer (see Table X5.1) with suitable range and estimated measurement uncertainty of 0.02 °C [0.04 °F] or less at 95 % confidence interval listed on the calibration certificate and is one of the following:

6.2.1 A liquid-in-glass thermometer that is calibrated annually. The calibration shall be verified at the ice point in accordance with Appendix X5. ASTM Kinematic Viscosity Thermometers 47C and 47F conforming to Specification E1 are suitable for the most commonly used temperature of 60 °C [140 °F].

NOTE 5—The specified thermometers in 6.2.1 are standardized as "total immersion" thermometers, which are designed to indicate temperatures correctly when just that portion of the thermometer containing the liquid is exposed to the temperature being measured and the remainder of the stem and expansion chamber at the top of the thermometer exposed to the room temperature. The practice of completely submerging the thermometer is not recommended. When a "total immersion" thermometer is completely submerged, corrections for each individual thermometer based on calibration under conditions of complete submergence must be determined and applied. If the thermometer is completely submerged in the bath during use, the pressure of the gas in the expansion chamber will be higher or lower than during calibration, and may cause high or low readings on the thermometer.

6.2.2 A platinum resistance thermometer (PRT) with a sensor which conforms to the requirements of Specification E1137/E1137M. The thermometer shall be calibrated annually as a single unit and have a three- or four-wire connection configuration. The sensing element shall be immersed to the depth specified by the manufacturer adjacent to the capillary tube.

NOTE 6—A minimum of 50 mm [2 in.] of the thermometer sheath (wire-connecting side) shall not be subjected to the bath medium unless otherwise specified by the manufacturer.

6.2.3 A thermistor thermometer with sensor, which conforms to the requirements of Specification E879, calibrated annually as a single unit. The sensing element of the thermistor shall be completely immersed in the bath adjacent to the capillary tube.

NOTE 7—The use of the thermometric devices specified in 6.2.2 and 6.2.3 are understood to introduce bias in the precision in this method.

6.3 *Bath*—A bath suitable for immersion of the viscometer so that the liquid reservoir or the top of the capillary, whichever is uppermost, is at least 20 mm below the upper surface of the bath liquid and with provisions for visibility of the viscometer and the thermometer. Firm supports for the viscometer shall be provided. The efficiency of the stirring and the balance between heat losses and heat input must be such that the temperature of the bath medium does not vary by more than ±0.03 °C

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D04-1003. Contact ASTM Customer Service at service@astm.org.