



Standard Test Method for Ductility of Asphalt Materials¹

This standard is issued under the fixed designation D113; 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.

1. Scope

1.1 This test method describes the procedure for determining the ductility of an asphalt material measured by the distance to which it will elongate before breaking when two ends of a briquet specimen of the material, of the form described in 4.1, are pulled apart at a specified speed and at a specified temperature. Unless otherwise specified, the test shall be made at a temperature of 25 ± 0.5 °C [77 ± 0.9 °F] and with a speed of 5 cm/min \pm 5.0 %. At other temperatures the speed should be specified.

1.2 Because of the large number of methods for obtaining test samples, it is impractical to discuss specific products in this test method. Refer to individual product specifications for guidance in obtaining a test sample.

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

1.4 The values stated in 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 each other. Combining values from the two systems may result in nonconformance with the standard. Bath and mold dimensions are given in SI units only, as the equipment is not available in inch-pound units.

1.5 **Warning**—Mercury has been designated by the United States Environmental Protection Agency 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)

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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for details and the EPA's website (<http://www.epa.gov/mercury/faq.htm>) for additional information. Users should be aware that selling mercury or mercury-containing products, or both, in your state may be prohibited by state law.

1.6 *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.*

1.7 *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
- D5/D5M Test Method for Penetration of Bituminous Materials
- D402/D402M Test Method for Distillation of Cutback Asphalt
- D1754/D1754M Test Method for Effects of Heat and Air on Asphaltic Materials (Thin-Film Oven Test)
- D2872 Test Method for Effect of Heat and Air on a Moving Film of Asphalt (Rolling Thin-Film Oven Test)
- D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
- D6934 Test Method for Residue by Evaporation of Emulsified Asphalt
- D6997 Test Method for Distillation of Emulsified Asphalt
- D7403 Test Method for Determination of Residue of Emulsified Asphalt by Low-Temperature Vacuum Distillation
- D7497 Practice for Recovering Residue from Emulsified

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.

- Asphalt Using Low Temperature Evaporative Technique
- 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
- E220 Test Method for Calibration of Thermocouples By Comparison Techniques
- E644 Test Methods for Testing Industrial Resistance Thermometers
- E1137/E1137M Specification for Industrial Platinum Resistance Thermometers
- E2251 Specification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids

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.

4. Apparatus

4.1 *Mold*—The mold shall be made of brass, 10.0 ± 0.1 mm thick, the ends *b* and *b'* being known as clips, and the parts *a* and *a'* as sides of the mold, with a brass base plate that is larger than the assembled mold. The dimensions of the assembled mold shall be as shown in Fig. 1 with the permissible variations indicated.

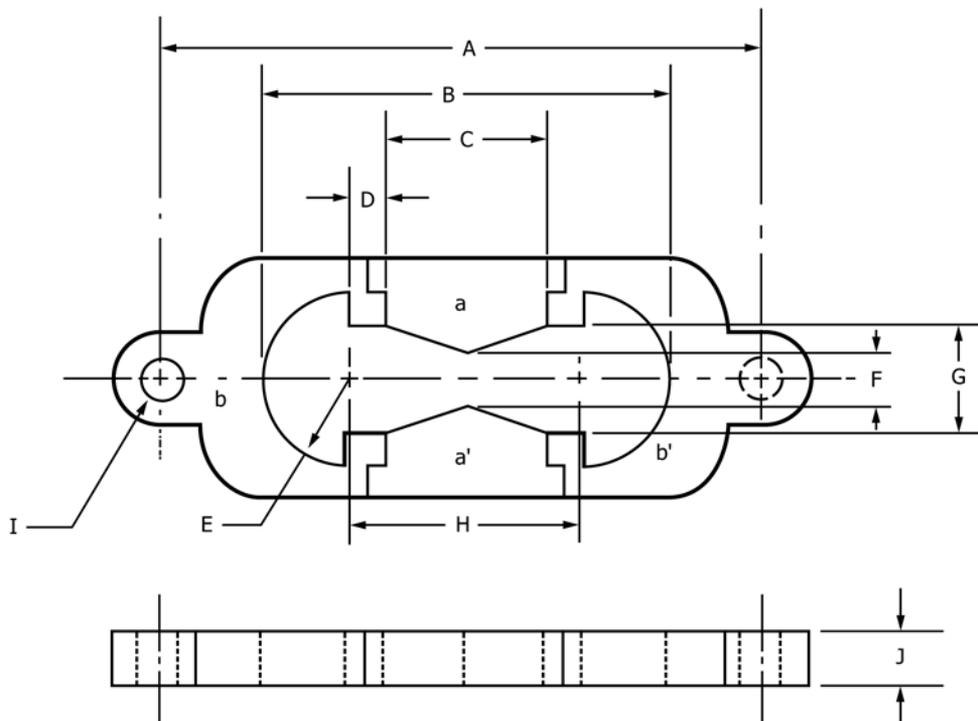
4.2 *Water Bath for Conditioning Specimens*—A water bath capable of maintaining the specified test temperature, varying not more than $0.5 \text{ }^\circ\text{C}$ [$0.9 \text{ }^\circ\text{F}$] from this temperature. The specimen shall be immersed to a depth of not less than 2.5 cm.

4.3 *Testing Machine*—For pulling the briquet of asphalt material apart, any apparatus may be used which is so constructed that the specimen will be continuously immersed in water, while the two clips are pulled apart at a uniform

3. Significance and Use

3.1 This test method provides one measure of tensile properties of asphalt materials and may be used to measure ductility for specification requirements.

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



- A – Distance between centers, 111.5 to 113.5 mm.
- B – Total length of briquet, 74.5 to 75.5 mm.
- C – Distance between clips, 29.7 to 30.3 mm.
- D – Shoulder, 6.8 to 7.2 mm.
- E – Radius, 15.75 to 16.25 mm.
- F – Width at minimum cross section, 9.9 to 10.1 mm.
- G – Width at mouth of clip, 19.8 to 20.2 mm.
- H – Distance between centers of radii, 42.9 to 43.1 mm.
- I – Hole diameter, 6.5 to 6.7 mm.
- J – Thickness, 9.9 to 10.1 mm.

FIG. 1 Mold for Ductility Test Specimen

speed, as specified, without undue vibration. A $\pm 5\%$ variation of test speed is permissible. The water in the tank of the testing machine shall cover the specimen both above and below it by at least 2.5 cm and shall be maintained within $\pm 0.5\text{ }^{\circ}\text{C}$ [$\pm 0.9\text{ }^{\circ}\text{F}$] of the test temperature. The testing machine shall incorporate a means by which the elongation at the time of rupture can be measured in centimeters.

4.4 Thermometer—A calibrated liquid-in-glass thermometer of suitable range with subdivisions and maximum scale error of $0.1\text{ }^{\circ}\text{C}$ [$0.2\text{ }^{\circ}\text{F}$] or any thermometric device of equal accuracy, precision, and sensitivity shall be used. Thermometers shall conform to the requirements of Specification **E1** or **E2251**. Other thermometric devices shall conform to the requirements of Specification **E1137/E1137M**. The thermometer used for the water bath shall be calibrated periodically in accordance with Test Method **E77**. An alternate thermometric device shall be calibrated periodically in accordance with Specification **E1137/E1137M** and Test Method **E220** or **E644**.

4.5 Release Agent—A mixture such as glycerin with Dextrin, talc, or Kaolin (china clay), used to coat the bottom and sides of mold to prevent the specimen from sticking to the mold. Other materials may be used for this purpose if they have been shown not to affect the physical properties of the test specimen.

4.6 Oven—An oven capable of maintaining within $\pm 5\text{ }^{\circ}\text{C}$ [$\pm 10\text{ }^{\circ}\text{F}$] of the temperature required to heat the sample so it is just fluid enough to pour.

4.7 Trimming Tool—A straight-edged putty knife or spatula wider than the specimen for trimming.

4.8 Specific Gravity Additive—A substance such as methyl alcohol, sodium chloride, or ethylene glycol used to adjust the specific gravity of the water bath to prevent specimen from coming to the surface of the water or touching the bottom of the bath. Other additives may be used if they have been shown not to affect the physical properties of the specimen.

4.9 Sieves—300- μm (No. 50) sieve, 3 in. in diameter, in accordance with Specification **E11**.

NOTE 2—In those cases where the ductility specimens are conditioned in the standard penetration bath at $25\text{ }^{\circ}\text{C}$ [$77\text{ }^{\circ}\text{F}$], the thermometer or equivalent thermometric device as prescribed for Test Method **D5/D5M** may be used.

5. Sample Preparation

5.1 Emulsified Asphalt Residue—If the sample is a residual product recovered from emulsified asphalt by means of Test Methods **D6934**, **D6997**, **D7403**, or Practice **D7497**, stir the contents and immediately pour portions of the residue into suitable molds for making the required tests. Residue obtained from lower-temperature emulsion recovery procedures shall be brought to a temperature of at least $135\text{ }^{\circ}\text{C}$ prior to pouring. If an emulsified asphalt residue does not meet the ductility requirements, this may be indicative of the presence of foreign matter. If it is suspected that there is foreign matter in the residue, the residue may be strained through a 300- μm (No. 50) sieve that has been preheated at $135\text{ }^{\circ}\text{C}$ [$275\text{ }^{\circ}\text{F}$] prior to pouring into the test molds.

5.2 Unaged Sample—If the sample is an asphalt binder, carefully heat the sample in a covered container to prevent local overheating until it has become sufficiently fluid to pour. Use an oven set at $135\text{ }^{\circ}\text{C}$ [$275\text{ }^{\circ}\text{F}$] for sample heating.

5.3 Aged Sample—If the sample is a conditioned residue obtained from Test Method **D1754/D1754M** or **D2872**, combine the residue into a single container, cover, and heat in an oven set at $135\text{ }^{\circ}\text{C}$ [$275\text{ }^{\circ}\text{F}$]. (See **Note 3**.)

5.4 Cut-Back Asphalt Residue—If the sample is a residual product recovered from cut-back distillation by means of Test Method **D402/D402M**, stir the heated residue and immediately pour portions of the residue into suitable molds for making the required tests.

NOTE 3—In those cases where the samples are not sufficiently fluid to pour at $135\text{ }^{\circ}\text{C}$ [$275\text{ }^{\circ}\text{F}$], higher temperatures may be used.

6. Procedure

6.1 Assemble three molds on a brass plate. Thoroughly coat the surface of the plate and interior surfaces of the sides *a* and *a'*, **Fig. 1**, of the mold with a thin layer of release agent to prevent the test material from sticking. The plate upon which the mold is placed shall be flat and level so that the bottom surface of the mold will be in contact throughout. After sample preparation as described in Section 5, thoroughly stir the sample and pour into the mold. In filling the mold, take care not to disarrange the pieces of the mold, thus distorting the specimen shape. Pour the material in a thin stream back and forth from end to end of the mold until the mold is more than level full. Allow the filled mold to cool to room temperature for $35\text{ }^{\circ}\text{C}$ [$5\text{ }^{\circ}\text{C}$]. Then place it in the water bath at test temperature for $35\text{ }^{\circ}\text{C}$ [$5\text{ }^{\circ}\text{C}$]. Remove the test specimens from the water bath, lightly dry top of mold with paper towel or cotton rag, then immediately trim the excess material with a hot trimming tool to make the molds just level full. (See **Note 4**.)

6.2 Keeping Specimen at Standard Temperature—Place the trimmed specimen and mold in the water bath at the specified temperature for $90\text{ }^{\circ}\text{C}$ [$5\text{ }^{\circ}\text{C}$] prior to testing. Remove the specimen from the plate by a shearing action between specimen and plate, avoiding any bending of the specimen.

6.3 Testing—Attach the rings at each end of the clips to the pins or hooks in the testing machine and ensure that side pieces *a* and *a'* have been removed. Pull the two clips apart at a uniform speed as specified until the specimen ruptures or reaches the length limitations of the testing machine. Measure the distance in centimetres through which the clips have been pulled to produce rupture or final length.

6.3.1 A normal test is one in which the material ruptures near the center of the specimen or reaches the length limitations of the testing machine. A rupture occurring at either clip shall not be considered normal.

6.3.2 If the sample comes in contact with the surface of the water or the bottom of the bath, the test shall not be considered normal. Adjust the specific gravity of the bath by using a specific gravity additive as described in 4.8 so that the test specimen neither comes to the surface of the water, nor touches the bottom of the bath at any time during the test. (See **Note 5**.)

NOTE 4—A critical dimension of the ductility mold is the width at the cross section of the mold. Measure and record the cross section distance and compare to the specifications listed in Fig. 1. In addition, best practice recommends etching a uniform identification of letters or numbers on the mold set clips and side pieces so that the mold pieces are used as a set.

NOTE 5—Some additives used to adjust the specific gravity of the water bath are toxic and can cause corrosion of the testing machine. If specific gravity adjustments have been made, it is recommended to wear gloves when placing hands in the bath fluid. Frequent bath fluid changes are recommended to prevent damage to the testing machine.

7. Report

7.1 Report the average of three normal tests as the ductility of the sample. If a normal test is not obtainable, report the ductility as being unobtainable under the conditions of the test. If rupture does not occur due to length limitations of the testing machine, report ductility as the length limitation in cm+ (for example, 150 cm+). If this testing is performed on less than three replicates of the same sample due to insufficient material, include the number of replicates used in the test report.

7.2 In the event of a discrepancy, the referee method shall be to perform the test using three replicates. If the discrepancy involves a distillation residue, pour the material through a 300-µm (No. 50) sieve that has been preheated at 135 ± 5 °C [275 ± 10 °F] prior to pouring into test molds. Report the average of three normal tests as the ductility of the sample.

8. Precision and Bias

8.1 Criteria for judging the acceptability of ductility test results at 25 °C [77 °F] obtained by this test method are shown in Fig. 2. (See Notes 6-8.)

NOTE 6—The precision statement for ductility, as presented in Fig. 2, is based on tests performed on asphalt binders. The precision of tests on residues, such as those obtained by Test Methods D1754/D1754M and D2872, have not been established.

NOTE 7—The numbers plotted in Fig. 2 represent the (1S) and (D2S) limits for single-operator precision and multi-laboratory precision as described in Practice C670.

NOTE 8—Insufficient data are available to properly define precision at 15.6 °C [60 °F]. However, analysis of data resulting from tests by 13 laboratories on one asphalt for which the average ductility test result was 45 cm shows a multi-laboratory precision (D2S) of 23 cm.

9. Keywords

9.1 ductility; ductility mold; ductilometer

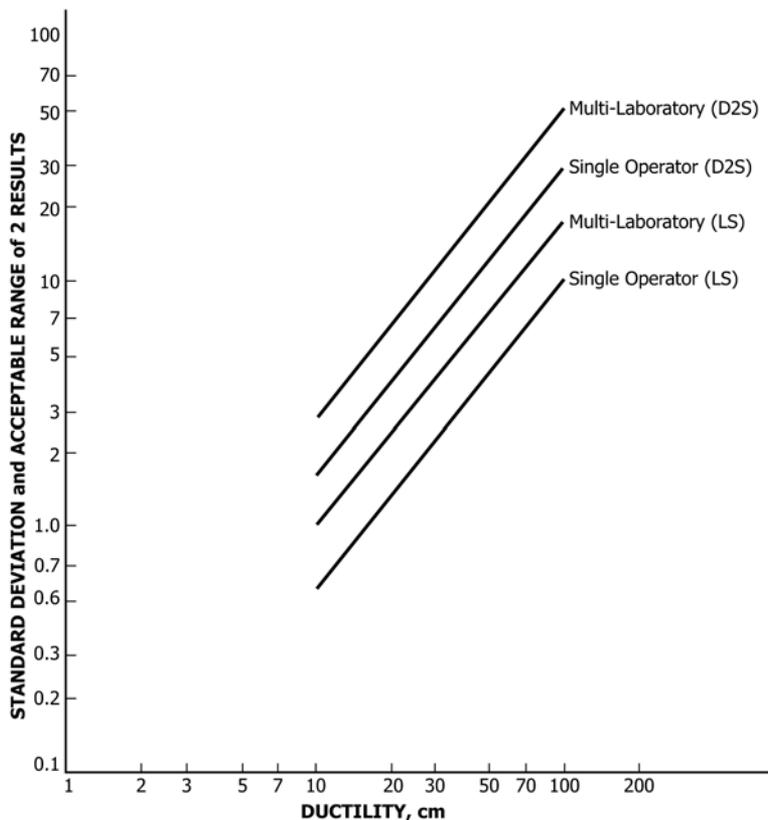


FIG. 2 Precision Data

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