



Designation: D5/D5M – 20

Standard Test Method for Penetration of Bituminous Materials¹

This standard is issued under the fixed designation D5/D5M; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers determination of the penetration of semi-solid and solid bituminous materials.

1.2 The needles, containers, and other conditions described in this test method provide for the determinations of penetrations up to 500.

NOTE 1—See the section on Penetration of Test Methods D244 for information and precision and bias on testing emulsion residue.

1.3 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.

1.4 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.

1.5 *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.*

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.

Current edition approved May 1, 2020. Published May 2020. Originally approved in 1959. Last previous edition approved in 2019 as D5/D5M – 19a. DOI: 10.1520/D0005_D0005M-20.

2. Referenced Documents

2.1 *ASTM Standards:*²

D8 Terminology Relating to Materials for Roads and Pavements

D36/D36M Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)

D244 Test Methods and Practices for Emulsified Asphalts

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

D8055 Guide for Selecting an Appropriate Electronic Thermometer for Replacing Mercury Thermometers in D04 Road and Paving Standards

E1 Specification for ASTM Liquid-in-Glass Thermometers

E77 Test Method for Inspection and Verification of Thermometers

E563 Practice for Preparation and Use of an Ice-Point Bath as a Reference Temperature

E644 Test Methods for Testing Industrial Resistance Thermometers

2.2 *ANSI Standard:*³

B46.1 Surface Texture

2.3 *ISO Standard:*³

ISO Standard 468 Surface Roughness—Parameters, Their Values and General Rules for Specifying Requirements

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

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 National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

3.2.1 *penetration, n*—consistency of a bituminous material expressed as the distance in tenths of a millimetre that a standard needle vertically penetrates a sample of the material under known conditions of loading, time, and temperature.

4. Summary of Test Method

4.1 The sample is melted (if starting at ambient temperature) and cooled under controlled conditions. The penetration is measured with a penetrometer by means of which a standard needle is applied to the sample under specific conditions.

5. Significance and Use

5.1 The penetration test is used as a measure of consistency. Higher values of penetration indicate softer consistency.

NOTE 2—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 *Penetration Apparatus*—Any apparatus that permits the needle holder (spindle) to move vertically without measurable friction and is capable of indicating the depth of penetration to the nearest 0.1 mm will be acceptable. The weight of the spindle shall be 47.5 ± 0.05 g. The total weight of the needle and spindle assembly shall be 50.0 ± 0.05 g. Weights of 50 ± 0.05 g and 100 ± 0.05 g shall also be provided for total loads of 100 and 200 g, as required for some conditions of the test. The surface on which the sample container rests shall be flat, and the axis of the plunger shall be at approximately 90° to this surface. The apparatus shall have a leveling indicator. The spindle shall be easily detached for checking its weight.

6.1.1 The leveling indicator shall be verified at least annually with a handheld level.

6.2 Penetration Needle:

6.2.1 The needle (see Fig. 1) shall be made from fully hardened and tempered stainless steel, Grade 440-C or equal, HRC 54 to 60. The standard needle shall be approximately 50 mm [2 in.] in length, the long needle approximately 60 mm [2.4 in.]. The diameter of all needles shall be 1.00 to 1.02 mm [0.0394 to 0.0402 in.]. It shall be symmetrically tapered at one end by grinding to a cone having an angle between 8.7 and 9.7° over the entire cone length. The cone shall be coaxial with the straight body of the needle. The total axial variation of the

intersection between the conical and straight surfaces shall not be in excess of 0.2 mm [0.008 in.]. The truncated tip of the cone shall be within the diameter limits of 0.14 and 0.16 mm [0.0055 and 0.0063 in.] and square to the needle axis within 2° . The entire edge of the truncated surface at the tip shall be sharp and free of burrs. When the surface texture is measured in accordance with American National Standard B46.1 or ISO 468 the surface roughness height, R_a , of the tapered cone shall be 0.2 to 0.3 μm [8 to 12 $\mu\text{in.}$] arithmetic average. The surface roughness height, R_a , of the needle shank shall be 0.025 to 0.125 μm [1 to 5 $\mu\text{in.}$]. The needle shall be mounted in a non-corroding metal ferrule. The ferrule shall be 3.2 ± 0.05 mm [0.126 ± 0.002 in.] in diameter and 38 ± 1 mm [1.50 ± 0.04 in.] in length. The exposed length of the standard needle shall be within the limits of 40 to 45 mm [1.57 to 1.77 in.], and the exposed length of the long needle shall be 50 to 55 mm [1.97 to 2.17 in.]. The needle shall be rigidly mounted in the ferrule. The run-out (total indicator reading) of the needle tip and any portion of the needle relative to the ferrule axis shall not exceed 1 mm [0.04 in.]. The weight of the ferrule needle assembly shall be 2.50 ± 0.05 g. (A drill hole at the end of the ferrule or a flat on the side is permissible to control the weight.) Individual identification markings shall be placed on the ferrule of each needle; the same markings shall not be repeated by a manufacturer within a three-year period.

6.2.2 Needles used in testing materials for conformance to specifications shall be shown to have met the requirements of 6.2.1. Needles shall be checked every twelve months.

6.3 *Sample Container*—A metal or glass cylindrical, flat-bottom container of essentially the following dimensions shall be used:

For penetrations below 40:	
Diameter, mm	33–50
Internal depth, mm	8–16
For penetrations below 200:	
Diameter, mm	48–56
Internal depth, mm	34–40
For penetrations between 200 and 350:	
Diameter, mm	55–80
Internal depth, mm	45–70
For penetrations 350 to 500	
Diameter, mm	55–70
Internal depth, mm	70–80

NOTE 3—Commonly available metal container sizes are 33 by 8 mm, 40 by 15 mm, 55 by 35 mm, 70 by 45 mm, 80 by 50 mm, and 70 by 80 mm.

6.3.1 For referee testing, the container shall essentially be 55 by 35 mm for materials with penetrations below 200; 70 by 45 mm for penetrations between 200 and 350; and 70 by 80 mm for penetrations above 350.

6.4 *Water Bath*—A bath capable of maintaining a temperature of 25 ± 0.1 $^\circ\text{C}$ [77 ± 0.2 $^\circ\text{F}$] or any other temperature of test within 0.1 $^\circ\text{C}$ [0.2 $^\circ\text{F}$]. The bath shall have a perforated shelf supported in a position not less than 50 mm from the bottom and not less than 100 mm below the liquid level in the bath. If penetration tests are to be made in the bath itself, an additional shelf strong enough to support the penetrometer shall be provided. Brine may be used in the bath for determinations at low temperatures.

NOTE 4—The use of distilled water is recommended for the bath. Take care to avoid contamination of the bath water by surface active agents,

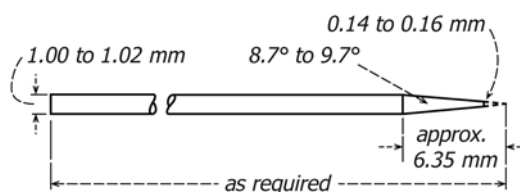


FIG. 1 Needle for Penetration Test

release agents, or other chemicals, as their presence may affect the penetration values obtained.

6.5 Transfer Dish—When used, the transfer dish shall have a capacity of at least 350 mL and sufficient depth of water to cover the large sample container. It shall be provided with some means for obtaining a firm bearing and preventing rocking of the container. A three-legged stand with three-point contact for the sample container is a convenient way of ensuring this.

6.6 Timing Device—For hand-operated penetrometers, any convenient timing device such as an electric timer, a stop watch, or other spring-activated device may be used provided it is graduated in 0.1 s or less and is accurate to within ± 0.1 s for a 60-s interval. An audible seconds counter adjusted to provide one beat each 0.5 s may also be used. The time for an eleven-count interval shall be 5 ± 0.1 s. Any automatic timing device attached to a penetrometer shall be accurately calibrated to provide the desired test interval within ± 0.1 s.

6.7 Thermometer—A thermometer, to be used in measuring the temperature of the water bath described in 6.2 while completing the test procedure as described in Section 9. The thermometer shall be one of the following (see Note 5):

6.7.1 A liquid-in-glass partial immersion thermometer of suitable range with subdivisions and maximum scale error of 0.1 °C [0.2 °F] which conforms to the requirements of Specification E1. Standardize the thermometer in accordance with one of the methods in Test Method E77 or verify its original standardization at the ice point in accordance with Practice E563. If the thermometer does not read 0.0 ± 0.1 °C [32.0 ± 0.2 °F] at the ice point, then the thermometer should be re-standardized.

6.7.1.1 Suitable liquid-in-glass thermometers commonly used are:

ASTM Number	Range
17C or 17F	19 to 27 °C [66 to 80 °F]
63C or 63F	-8 to +32 °C [18 to 89 °F]
64C or 64F	25 to 55 °C [77 to 131 °F]

6.7.2 A platinum resistance thermometer (PRT) readable to the nearest 0.1 °C [0.2 °F], with a Pt 100 Class AA tolerance rating and either a three- or four-wire configuration and an overall sheath length at least 50 mm [2 in.] greater than the immersion depth. Standardize the PRT system (probe and readout device) in accordance with Test Methods E644. Corrections shall be applied to ensure accurate measurements within 0.1 °C [0.2 °F].

6.7.3 A metal-sheathed thermistor readable to the nearest 0.1 °C [0.2 °F] with an overall sheath length at least 50 mm [2 in.] greater than the immersion depth. Standardize the thermistor system (probe and readout device) in accordance with Test Methods E644. Corrections shall be applied to ensure accurate measurements within 0.1 °C [0.2 °F].

NOTE 5—Guide D8055 provides additional guidance on selecting appropriate electronic thermometer alternatives to a mercury-in-glass thermometer.

7. Preparation of Test Specimen

7.1 If the sample is not sufficiently fluid as received, heat the sample with care, stirring when possible to prevent local

overheating, until it has become sufficiently fluid to pour. In no case should the temperature be raised to more than 60 °C [140 °F] above the expected softening point for tar pitch in accordance with Test Method D36/D36M, or to more than 90 °C [194 °F] above it for petroleum asphalt (bitumen). Heat samples for the minimum time necessary to ensure that they are sufficiently fluid. Stir to ensure that the sample is homogeneous. Avoid incorporating bubbles into the sample.

7.2 Pour the sample into the sample container to a depth such that, when cooled to the temperature of test, the depth of the sample is at least 120 % of the depth to which the needle is expected to penetrate. Pour separate portions for each variation in test conditions. If the sample container is less than 65 mm in diameter and the expected penetration is greater than 200, pour three separate portions for each variation in test conditions.

NOTE 6—If sufficient material is available, it is recommended to fill the sample container to near the brim.

7.3 Allow to cool in air at a temperature between 15 and 30 °C [59 and 86 °F]. Then place the samples together with the transfer dish, if used, in the water bath maintained at the prescribed temperature of test. Use the cooling and water bath times below:

Container size, mm	Cooling Time, min	Water Bath Time, min
33 × 8	20 to 40	20 to 40
33 × 16 or less	45 to 90	45 to 90
55 × 35	60 to 90	60 to 90
Larger	90 to 120	90 to 120

NOTE 7—If conditions warrant, it is appropriate to loosely cover each container as a protection against dust. A convenient way of doing this is by covering with a lipped beaker or inverted watch glass.

8. Test Conditions

8.1 Where the conditions of test are not specifically mentioned, the temperature, load, and time are understood to be 25 °C [77 °F], 100 g, and 5 s, respectively. Other conditions may be used for special testing, such as the following:

Temperature, °C [°F]	Load, g	Time, s
0 [32]	200	60
4 [39.2]	200	60
45 [113]	50	5
46.1 [115]	50	5

In such cases, the specific conditions of test shall be reported.

9. Procedure

9.1 Examine the needle holder and guide to establish the absence of water and other extraneous materials. If the penetration is expected to exceed 350, use a long needle; otherwise, use a short needle. Clean a penetration needle with toluene or other suitable solvent, dry with a clean cloth, and insert the needle into the penetrometer. Unless otherwise specified, place the 50-g weight above the needle, making the total weight 100 ± 0.1 g.

9.2 If tests are to be made with the penetrometer in the bath, place the sample container directly on the submerged stand of the penetrometer. Keep the sample container completely covered with water in the bath. If the tests are to be made with the penetrometer outside the bath, place the sample container in the transfer dish, cover the container completely with water