Designation: D6857/D6857M – 17

Standard Test Method for Maximum Specific Gravity and Density of Asphalt Mixtures Using Automatic Vacuum Sealing Method[1]

This standard is issued under the fixed designation D6857/D6857M; 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 maximum specific gravity and density of uncompacted asphalt mixtures at 25 °C [77 °F].

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 equivalent; 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 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 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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

D979/D979M Practice for Sampling Bituminous Paving Mixtures

D2041/D2041M Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

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

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E1547 Terminology Relating to Industrial and Specialty Chemicals

3. Terminology

3.1 The terms 'specific gravity' and 'density' used in this test method are in accordance with the Terminology E1547.

3.2 *Definitions:*

3.2.1 *density, as determined by this test method*—the mass of a cubic meter of the material at 25 °C in SI units, or the mass of a cubic foot of the material at 77 °F in inch-pound units.

3.2.2 *residual pressure, as employed by this test method*—the pressure in a vacuum chamber when vacuum is applied.

3.2.3 *specific gravity, as determined by this test method*—the ratio of a given mass of material at 25 °C [77 °F] to the mass of an equal volume of water at the same temperature.

4. Summary of Test Method

4.1 A weighed sample of oven-dry asphalt mixture in the loose condition at room temperature is placed inside a specially designed channel bag. The bag containing the sample is placed inside another bag and placed inside a vacuum chamber. Air is evacuated from the sample to an absolute pressure of 6.0 mm Hg [6 Torr] and is automatically sealed. The bags containing the sample are removed from the vacuum chamber and placed inside a large water tank equipped with scales for weighing the sample under water. While completely submerged, the bag is cut open by scissors to allow the water to enter the bag. Since the sample is under complete vacuum, water will be forced around all the accessible areas of the sample. The difference in weight in air and suspended weight in water will provide the sample volume after correcting for the bag influence. The dry weight and the volume can be used to calculate the maximum

[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.21 on Specific Gravity and Density of Asphalt Mixtures.

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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.

specific gravity of the sample. This method is a rapid technique for determination of maximum specific gravity that minimizes the exposure of asphalt mixture samples to water during testing and reduces the chance of water absorption.

NOTE 1—For porous aggregates, if water absorption correction is not performed on the maximum specific gravities obtained using this test method, the results may be higher than the results obtained by Test Method D2041/D2041M. Without aggregate water absorption correction, air voids calculated based on these results may be higher.

5. Significance and Use

5.1 The maximum specific gravities and densities of asphalt mixtures are intrinsic properties whose values are influenced by the composition of the mixture in terms of types and amounts of aggregates and asphalt materials.

5.1.1 They are used to calculate values for percent air voids in compacted asphalt mixtures.

5.1.2 They provide target values for the compaction of asphalt mixtures.

5.1.3 They are essential when calculating the amount of asphalt binder absorbed by the internal porosity of the individual aggregate particles in an asphalt mixture.

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 *Balance,* with ample capacity, and with sufficient sensitivity to enable maximum specific gravity of specimens to be calculated to at least four significant figures, that is, to at least three decimal places. It shall be equipped with a suitable apparatus to permit weighing the specimen while it is suspended in water. The suspension wire attached to the scales should break the surface of the water at a single point and should have a maximum diameter of 3 mm [0.125 in.]. The balance shall conform to Guide D4753 as a class GP2 balance.

NOTE 3—Since there are no more significant figures in the quotient (maximum specific gravity) than appear in either the dividend (the mass of the specimen in air) or in the divisor (the volume of the specimen, obtained from the difference in mass of the specimen in air and in water), this means that the balance must have a sensitivity capable of providing both mass and volume values to at least four figures. For example, a sensitivity of 0.1 g [0.00022 lb] would provide four significant figures for the determination of a mass in the range from 130.0 to 999.9 g [0.29 to 2.20 lb] when the specific gravity is 2.300.

6.2 *Water Bath,* with minimum dimensions (Length × Width × Depth) of 610 by 460 by 460 mm [24 by 18 by 18 in.] or a cylindrical container with a minimum diameter of 460 mm [18 in.] and minimum depth of 460 mm [18 in.], for completely submerging the specimen in water while suspended.

NOTE 4—Setting the water tank at waist level will enable the user to conduct this test while standing and will significantly simplify the weighing operations.

6.3 *Vacuum Chamber,*[3] with a 0.93 kW [1.25 hp] pump capable of evacuating a sealed and enclosed chamber to 5.6 mm Hg [6 Torr]. The chamber shall be large enough to seal samples as large as 2200 g [4.85 lb]. The device shall automatically seal the plastic bag and exhaust air back into the chamber in a controlled manner to ensure proper conformance of the plastic to the asphalt mixture. The air exhaust and vacuum operation time should be calibrated at the factory prior to initial use. The air exhaust system should be calibrated to bring the chamber to atmospheric pressure in 80 to 150 s, after the completion of the vacuum operation. The vacuum system should be provided with a latch to control the chamber door opening.

6.4 *Absolute Vacuum Measurement Gauge,* independent of the vacuum sealing device which may be placed directly inside the chamber to verify vacuum performance and the chamber door sealing condition of the unit. The gauge shall be capable of reading pressure to 3 mm Hg [3 Torr].

6.5 *Plastic Bags,* consisting of inner plastic bag (internal bag) having random channels built into one side of the bag, with minimum and maximum bag opening sizes of 305 mm [12 in.] and 340 mm [13.5 in.], respectively, and outer plastic bag (external bag) with minimum and maximum opening sizes of 375 mm [14.75 in.] and 394 mm [15.5 in.], respectively. The bags shall be of plastic material that will not adhere to asphalt film, is puncture resistant, and is impermeable to air. Each bag shall have a minimum thickness of 0.100 mm [0.004 in.] and maximum thickness of 0.152 mm [0.006 in.]. The combined apparent specific gravity of the two bags shall be provided by the manufacturer.

NOTE 5—Protect the plastic bags during storage. Rough handling, storing in close proximity to sharp objects, near aggregates, or inside drawers will damage the plastic bags. Refer to the manufacturer's procedures for safe handling and storage of bags.

6.6 *Holder,* for water displacement of the sample having no sharp edges.

6.7 *Filler Plates,* to position the sample and the bags in the same plane as the sealing bar.

6.8 *Bag-Cutting Knife,* or scissors.

6.9 *Thermometric Device,* a temperature-measuring device readable to 0.5 °C [1 °F] and accurate to 0.3 °C [0.5 °F] for monitoring the temperature of the water bath.

6.10 *Laboratory Oven,* capable of heating the asphalt sample to 110 ± 5 °C [230 ± 9 °F]

7. Sampling

7.1 Obtain the sample in accordance with Practice D979/D979M.

7.2 The size of the sample shall conform to the following requirements. Samples larger than 2200 g [4.85 lb] may be tested in 1500 to 2000 g [3.31 to 4.41 lb] portions at a time.

[3] The sole source of supply of the apparatus and the method known to the committee at this time is InstroTek, Inc., Raleigh, NC. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

Size of Largest Particle of Aggregate in Mixture, mm [in.]	Minimum Sample Size, g
50.0 [2]	6000[13.23]
37.5 [1.5]	4000[8.82]
25.0 [1]	2500[5.51]
19.0 [0.75]	2000[4.41]
12.5 [0.5]	1500[3.31]
9.5 [0.375]	1500[3.31]
4.75 [0.187]	1500[3.31]

8. Procedure

8.1 Separate the particles of the sample of asphalt mixture by hand, taking care to avoid fracturing the aggregate, so that the particles of the fine aggregate portion are not larger than 6.3 mm [¼ in.]. If a sample of asphalt mixture is not sufficiently soft to be separated manually, place it in a flat pan and warm it in an oven until it can be separated as described.

8.2 Unless the asphalt mixture has been prepared in a laboratory using oven-dry aggregates, oven dry the sample to a constant mass at a temperature of 110 ± 5 °C [230 ± 9 °F]. Other methods of drying can be used as long as the sample achieves a constant mass (mass repeats within 0.1 %). This drying, and any required warming for particle separation as described in 8.1, should be combined as a single operation to minimize reheating effects.

8.3 Cool the sample to room temperature and record the weight. (Refer to Column B of the data collection table. See Table X1.1 in the Appendix.)

8.4 Set the vacuum sealing machine according to the manufacturer's recommendation to create 99 % of absolute vacuum for a minimum of 5 min inside the chamber.

NOTE 6—For asphalt mixtures that contain polymers, follow the manufacturer's recommendations.

8.5 If after examining the external bag there are no punctures or cuts, weigh one channel (internal) and one examined non channel (external) bag.

8.6 Record the combined weight of the bags in Column A of the attached data collection table.

8.7 Place the sample in the internal bag. Ensure that no sample is lost during this transfer.

8.8 Place the empty external bag inside the vacuum chamber.

8.9 Place the internal bag containing the sample with the channel side (rough side) down into the external bag. The rough side is placed under the sample to protect against trapped air and to help in the evacuation of the air from the bag.

8.10 Spread the sample so that it is evenly distributed within the internal bag. Do not spread the sample by squeezing down on the sample from outside the bag.

8.11 Push in the opening of the internal bag away from the opening of the external bag to prevent the opening of the internal bag from being sealed. Make sure that the opening of the internal bag is flat and that the opening is not restricted by a fold in the bag.

8.12 Place the opening of the external bag over the seal bar, making sure the internal bag is not over the seal bar.

8.13 Close the chamber door.

8.14 Allow the vacuum chamber to remove the air from the chamber and the plastic bag. Follow the manufacturer's recommendations for proper machine settings and time required for the vacuum cycle. The vacuum chamber shall automatically seal the bag once the air is removed.

8.15 Exhaust air into the chamber until the chamber door opens, indicating atmospheric pressure within the chamber. The chamber door latch can be used to avoid automatic opening of the door after completion of the test.

8.16 Remove the sealed sample from the vacuum chamber. Perform a visual inspection of the bag and listen for any leaks.

NOTE 7—While transferring the sample to the water bath, handle the sealed sample with extreme care. Avoid impact with hard surfaces. Impact can cause leaks in the bag and allow air to enter the sample.

8.17 Immediately transfer the sample to the water bath at 25 ± 1 °C [77 ± 2 °F] equipped with a scale.

8.18 Submerge the sealed bag containing the sample completely underwater and cut open the external bag all the way across the top, leaving approximately 25 mm [1 in.] intact. When cutting the bag, make certain the sealed portion of the bag is at least 50 mm [2 in.] underwater and remains underwater throughout the entire process.

8.19 Open both bags with your fingers and hold open for 10 to 15 s to allow the water to flow in the bags.

8.20 Secure the sample over a suspended scale. Make certain the bags or the suspension equipment is not contacting the sides or the bottom of the water tank and that no part of the plastic bag is breaking the water surface at any time.

8.21 Record the weight in Column C of the data collection table.

8.22 Perform the calculation according to Section 9 or use computer software for automatic calculation of the maximum specific gravity.

9. Calculations

9.1 Calculate the maximum specific gravity of the asphalt mixture as follows:

$$\text{Maximum Specific Gravity} = \frac{B}{A + B - C - \frac{A}{V_c}} \quad (1)$$

where:

B = mass of dry specimen in air, g,
A = combined mass of two plastic bags, (one channel and one external bag), g,
C = mass of asphalt mixture and the bags underwater, g, and
V_c = combined apparent specific gravity of the two plastic bags at 25 °C [77 °F], provided by the manufacturer.

9.2 Calculate the density of the specimen as follows:

$$\text{Density} = (\text{Maximum Specific Gravity})\,\gamma \quad (2)$$

where:

γ = density of water at 25 °C [77 °F] (997.0 kg/m^3, 0.997 g/cm^3 or 62.24 lb/ft^3).

10. Verification

10.1 The vacuum settings of the device should be verified once every three months, after major repairs, after each shipment or relocation. Verification should be performed with an absolute vacuum gauge capable of being placed inside the chamber and reading the vacuum setting of the sealing device.

10.2 Place the gauge inside the chamber and record the vacuum setting. The gauge should indicate a pressure reading of 6.0 mm Hg [6 Torr] or less. The unit should not be used if the gauge reading is above 8 mm Hg [8 Torr].

10.3 Vacuum gauge used for verification shall be standardized once every twelve months.

NOTE 8—On line vacuum gauges, while capable of indicating vacuum performance of the pump, are not suitable for use in enclosed vacuum chambers and can not accurately measure vacuum levels.

11. Report

11.1 Report the following information:

11.1.1 Apparent specific gravity of plastic bag to three decimal places.

11.1.2 Maximum specific gravity at 25 ± 1 °C [77 ± 2 °F] to four significant figures.

11.1.3 Density 25 ± 1 °C [77 ± 2 °F] to four significant figures.

12. Precision and Bias

12.1 The criteria for judging the acceptability of density test results obtained by this method are given below. The method to assess the precision of the inter-laboratory testing data was in accordance with Practice E691.

Type	Standard Deviation (1s)	Acceptable Range of Two Results (d2s)
Single Operator Precision	0.007	0.020
Multilaboratory Precision	0.009	0.026

The above estimate is based on three different mixes with different aggregate composition, gradation, binder type, and percent binder content. Mixes used for determination of the above precision values were all plant-produced mixes.

12.2 The figure given in Column 2 is standard deviation that has been found to be appropriate for the conditions of test described in Column 1. The figure given in Column 3 is the limit that should not be exceeded by the difference between the results of two properly conducted tests.

12.3 The value in Column 3 is the acceptable range for two tests. When more than two tests are being evaluated, the range given in Column 3 must be increased. Multiply the standard deviation in Column 2 by the multiplier given in Table 1 of Practice E691 for the number of actual tests. Additional guidance and background are given in Practice E691.

12.4 There is no true value of material maximum specific gravity available. Therefore, no statement on bias can be made for the measurement in this inter-laboratory study.

13. Keywords

13.1 asphalt mixture; asphalt mixtures – loose; density; maximum specific gravity

APPENDIX

(Nonmandatory Information)

X1. DATA COLLECTION TABLES

X1.1 Refer to Table X1.1.

TABLE X1.1 Maximum Specific Gravity Data Collection and Calculation Table (Sample)

NOTE 1—V_C = Bag volume correction provided by the device manufacturer.

Sample #	**A** Weight of Bags (grams)	**B** Weight of Sample in Air (grams)	**C** Weight of Bags and Sample in Water (grams)	**D** (A + B) – C Total Volume in Water	**E** A/V_c Volume of the Bags	**F** D – E Volume of the Sample	**G** B/F Max Specific Gravity (g/cm^3)