Designation: D 6857 – 03

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

This standard is issued under the fixed designation D 6857; 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 of and density of uncompacted bituminous paving mixtures at 25°C (77°F).

1.2 The values stated in SI units are to be regarded as the standard. The other units given may be approximate and are given to help the user interpret units on available standard equipment used with this test method.

1.3 *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.*

1.4 A multi-laboratory precision for this standard has not been developed at this time. This standard should not be used for acceptance or rejection of a material for purchasing purposes.

2. Referenced Documents

2.1 *ASTM Standards:*

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials[2]

D 979 Practice for Sampling Bituminous Paving Mixtures[3]

D 2041 Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures[3]

D 4311 Practice for Determination of Asphalt Volume Correction to Base Temperature[3]

D 4753 Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Soil, Rock, and Construction Materials Testing[4]

E 1 Specification for ASTM Thermometers[5]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method [6]

E 1547 Terminology Relating to Industrial and Specialty Chemicals[7]

3. Terminology

3.1 The terms specific gravity and density used in this test method are in accordance with the Terminology E 1547.

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 25°C 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 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 paving 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 5.6 mm Hg 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 specific gravity of the sample. This method is a rapid technique for determination of maximum specific gravity that minimizes the exposure of bituminous 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 D 2041. Without aggregate water absorption correction, air voids calculated based on these results may be higher.

[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 Bituminous Mixtures.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.03.

[4] *Annual Book of ASTM Standards*, Vol 04.08.

[5] *Annual Book of ASTM Standards*, Vol 14.03.

[6] *Annual Book of ASTM Standards*, Vol 14.02.

[7] *Annual Book of ASTM Standards*, Vol 15.05.

5. Significance and Use

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

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

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

5.1.3 They are essential when calculating the amount of bitumen absorbed by the internal porosity of the individual aggregate particles in a bituminous paving mixture.

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 Specification D 4753 as a class GP2 balance.

NOTE 2—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 would provide four significant figures for the determination of a mass in the range from 130.0 to 999.9 g when the specific gravity is 2.300.

6.2 *Water Bath*, with minimum dimensions (Length × Width × Depth) of 610 × 460 × 460 mm (24 × 18 × 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 3—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*[8], with a 0.93 kW (1.25 hp) pump capable of evacuating a sealed and enclosed chamber to 5.6 mm Hg. The chamber shall be large enough to seal samples as large as 2000 g. 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.

[8] 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.

6.4 *Absolute Vacuum Measurement Gage*, 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 gage shall be capable of reading pressure to 3 mm Hg.

6.5 *Plastic Bags, (Internal Bags)*, shall have random channels built into at least one side of the bag to aid in evacuating all the air from the sample. The internal bag shall have a minimum opening of 305 mm (12 in.) and maximum opening of 340 mm (13.5 in.) and the outside plastic bag (external bag) shall have a minimum opening of 375 mm (14.75 in.) and a maximum opening of 394 mm (15.5 in.). The bags shall be of plastic material that will not adhere to asphalt film, is puncture resistant, and is impermeable to air. The bags 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 4—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 manufacturers 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 Thermometers, calibrated liquid-in-glass thermometers of suitable range with subdivisions and maximum scale error of 0.5°C (0.9°F), or any other thermostatic device of equal accuracy, precision and sensitivity shall be used. Thermometers shall conform to the requirements of Specification E 1.

7. Sampling

7.1 Obtain the sample in accordance with Practice D 979.

7.2 The size of the sample shall conform to the following requirements. Samples larger than 2000 g may be tested in 1500-2000 g portions at a time.

Size of Largest Particle of Aggregate in Mixture, mm (in.)	Minimum Sample Size, g
50.0 (2)	6000
37.5 (1.5)	4000
25.0 (1)	2500
19.0 (0.75)	2000
12.5 (0.5)	1500
9.5 (0.375)	1500
4.75 (No. 4)	1500

8. Procedure

8.1 Separate the particles of the sample of paving 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 paving 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 paving mixture has been prepared in a laboratory using oven dry aggregates, oven-dry the sample to a constant mass at a temperature of 105 ± 5°C (221 ± 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 X1.2 in the Appendix).

8.4 Set the vacuum sealing machine according to the manufacture's recommendation to create at least a 5.6 mm Hg absolute pressure inside the chamber.

NOTE 5—For asphalt mixture that contain polymers, the vacuum setting should be held at 99 % of absolute vacuum for a minimum of five min. Follow manufacturers recommendations when performing tests on polymerized mixtures.

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. Enure 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. 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 6—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°C (77°F) equipped with a scale.

8.18 Submerge the sealed bag containing the sample completely under water 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.) under water and remains under water 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 Reach into the bag with one hand and for 40 to 60 s break down all clumps with your fingers until there are no clumps larger than the maximum aggregate size used in the mixture. With the other hand, fold the opening of the bag around the arm that is used for breaking the sample.

8.21 Secure the sample over a suspended scale and allow the weight to stabilize. 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.

8.22 Allow the scales to stabilize, and record the weight in column C of the data collection table.

8.23 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 paving 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 paving 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).

9.3 *Correction for Water Bath Temperature Other Than 25°C (77°F)*:

9.3.1 For a difference of water temperature less than or equal to 3°C (5.4°F) from 25°C (77°F), determine the maximum specific gravity as follows:

$$\text{Maximum Specific Gravity at 25°C} = K\,(\text{Maximum Specific Gravity at other temperature}) \quad (3)$$

where:

K = determined from Table X1.1.

NOTE 7—It is preferable to keep the water temperature constant by using temperature control equipment.

9.3.2 For a difference of water temperature greater than 3°C (5.4°F) from 25°C (77°F), determine the maximum specific gravity by using 9.3.1 and the correction based on the following equation:

$$\text{Correction} = \Delta T\,K_s\left(A + B - C - \frac{A}{V_c}\right) \quad (4)$$

where:

ΔT = 25°C minus the temperature of the water bath,

K_s = 6×10^{-5} ml/ml/°C average coefficient of cubical thermal expansion of bituminous concrete, and

$(A+B–C–(A/V_c)$ = mass of the volume of water for the volume of the specimen at 25°C.

9.3.3 The maximum specific gravity can be corrected for temperatures greater than 3°C (5.4°F), by the following equation:

$$\text{Maximum Specific Gravity} = \frac{B}{\left(A + B - C - \frac{A}{V_c} + \text{Correction}\right)} \quad (5)$$

9.3.4 Calculate the density of the specimen according to 9.2.

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 gage capable of being placed inside the chamber and reading the vacuum setting of the sealing device.

10.2 Place the gage inside the chamber and record the vacuum setting. The gage should indicate a pressure reading of 5.6 mm Hg or less. The unit should not be used if the gage reading is above 8 mm Hg.

10.3 Vacuum gage used for verification shall be calibrated for accuracy once every three years.

NOTE 8—On line vacuum gages, 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° ± 1.8°F) to four significant figures.

11.1.3 Density 25° ± 1°C (77° ± 1.8°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 in the following table:

Type	Standard Deviation (1s)	Acceptable Range of Two Results (d2s)
Single operator precision	7 kg/m^3	20 kg/m^3

The above estimate is based on six different mixes with different aggregate composition, gradation, binder type and percent binder content. Three of the mixes were laboratory and three were 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 3 must be increased. Multiply the standard deviation in column 2 by the multiplier given in Table number 1 of Practice E 691 for the number of actual tests.

Example for 3 *tests*: $7 \times 3.3 = 23.1$ (6)

Additional guidance and background is given in Practice E 691.

13. Keywords

13.1 bituminous paving mixtures—loose; density; maximum specific gravity; paving mixture

APPENDIX

(Nonmandatory Information)

X1. TEMPERATURE CONVERSION AND DATA COLLECTION TABLES

X1.1 Following are Table X1.1 and Table X1.2.

TABLE X1.1 Relative Density of Water and Conversion Factor *K* for Various Temperatures

Temperature, °C	Absolute Density of Water[A]	Correction Factor, *K*
10	0.999728	1.002661
11	0.999634	1.002567
12	0.999526	1.002458
13	0.999406	1.002338
14	0.999273	1.002204
15	0.999129	1.002060
16	0.998972	1.001903
17	0.998804	1.001734
18	0.998625	1.001555
19	0.998435	1.001364
20	0.998234	1.001162
21	0.998022	1.000950
22	0.997801	1.000728
23	0.997569	1.000495
24	0.997327	1.000253
25	0.997075	1.000000
26	0.996814	0.999738
27	0.996544	0.999467
28	0.996264	0.999187
29	0.995976	0.998898
30	0.995678	0.998599

[A] Data taken from Handbook of Chemistry and Physics, 55th ed., CRC Press, Inc.

TABLE X1.2 Maximum Specific Gravity Data Collection and Calculation Table (Sample)

Sample #	**A** Bag Weight (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 Bag	**F** D – E Volume of the Sample	**G** B/F Max Specific Gravity (g/cm^3)

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