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.

Designation: D7063/D7063M – 17

Standard Test Method for Effective Porosity and Effective Air Voids of Compacted Asphalt Mixture Samples[1]

This standard is issued under the fixed designation D7063/D7063M; 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 effective porosity or effective air voids of compacted mixtures by the use of a vacuum sealing method.

1.2 This method can be used for compacted field and laboratory asphalt mixture samples, as well as other compacted samples with well-defined geometrical shapes, such as concrete cylinders, cored rocks, and metal samples.

1.3 The results of this test method can be used to determine the degree of interconnectivity of air voids within a sample and can be correlated to permeability of compacted asphalt mixture samples.

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

1.5 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.

1.6 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.

1.7 *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 requirements prior to use.*

1.8 *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]

D8 Terminology Relating to Materials for Roads and Pavements

D979/D979M Practice for Sampling 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

D5361/D5361M Practice for Sampling Compacted Asphalt Mixtures for Laboratory Testing

D7227/D7227M Practice for Rapid Drying of Compacted Asphalt Mixture Specimens Using Vacuum Drying Apparatus

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

3. Terminology

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

4. Significance and Use

4.1 In this test method, a compacted sample is vacuum sealed inside a plastic bag. The density of the sample, SG1, is calculated using a water displacement method, with the sample sealed. With the sample still in water, the bag is cut open. Since the sample is under vacuum and the air voids are evacuated, water will rush in to fill all the water-accessible air voids in the compacted sample. With the saturated weight of sample known, an apparent maximum density, SG2, can be calculated. The difference between SG2 and SG1 is the measure of the amount of water that has penetrated the compacted sample.

[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.

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This difference can be used to determine the fraction of total number of voids that are accessible to water, effective percent porosity or percent effective air voids.

4.2 The results obtained from this method can be used to determine the percentage of total air voids in a compacted sample that can be filled with water through surface or interconnected paths within the sample. In general, effective percent porosity should be less than total percent air voids.

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 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.

4.3 This method can be used for 100-mm [4-in.] and 150-mm [6-in.] diameter cylindrical samples and cubical samples.

5. Apparatus

5.1 *Balance,* with ample capacity, and with sufficient sensitivity to enable bulk 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[3] to permit weighing the specimen while it is suspended in water. The balance shall conform to Guide D4753 as a class GP2 balance.

NOTE 2—Since there are no more significant figures in the quotient (bulk 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.

5.2 *Water Bath,* with minimum dimensions (length × width × depth) of 610 by 460 by 460 mm [24 by 18 by 18 in.] or a large cylindrical container with a minimum diameter of 460 mm and depth of 460 mm [18 by 18 in.], for completely submerging the specimen in water while suspended, equipped with an overflow outlet for maintaining a constant water level and temperature controls to maintain the water temperature at 25 ± 1 °C [77 ± 2 °F].

NOTE 3—It is preferable to keep the water temperature constant by using a temperature-controlled heater. Also, to reduce the chance for the bag to touch the sides of the water tank, it is preferable to elevate the water tank to a level at which the sample can be placed on the weighing mechanism while the operator is standing up (waist height), and the placement of the sample and the bag in the water tank can easily be inspected.

[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.

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

NOTE 4—To avoid accidental puncture of the plastic bags in the water bath, plastic-coated cushioned holders have been found to work well for this test method.

5.4 *Vacuum Chamber,* with a pump capable of evacuating a sealed and enclosed chamber to a pressure of 6 mm Hg [6 Torr], when at sea level. The chamber shall be large enough to test samples 150 mm [6 in.] wide by 350 mm [14 in.] long by 150 mm [6 in.] thick. 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 specimen. The air exhaust and vacuum operation time shall be set at the factory so that the chamber is brought to atmospheric pressure in 80 to 125 s, after the completion of the vacuum operation. The vacuum system shall be provided with a latch to control the chamber door opening.

5.5 *Vacuum Measurement Gage,* independent of the vacuum sealing device that could 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 down to 3 mm Hg [3 Torr] and readable to 1 mm Hg [1 Torr].

5.6 *Plastic Bags,* used with the vacuum device shall be one of the two following sizes. The smaller bags shall have a minimum opening of 235 mm [9.25 in.] and maximum opening of 260 mm [10.25 in.], and the larger bags 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, is capable of withstanding sample temperatures of up to 70 °C [158 °F], is impermeable and contains no air channels for evacuation of air from the bag. The bags shall have a minimum thickness of 0.127 mm [0.005 in.] and maximum thickness of 0.178 mm [0.007 in.]. The apparent specific gravity for the bags shall be provided by the manufacturer for each bag shipment. The apparent specific gravities provided for each size bag shall account for the different sample weights and bag weight used during testing.

5.7 *Specimen Sliding Plate,* used within the chamber for reduction of friction on the plastic bags.

5.8 *Bag-Cutting Knife,* or scissors.

5.9 *Thermometer,* readable to 1 °C [2 °F].

6. Verification

6.1 *System Verification:*

6.1.1 The vacuum settings of the device shall be verified once every three months, after major repairs, and after each shipment or relocation.

6.1.2 Place the gage inside the chamber and record the setting. The gage shall indicate a pressure of 6 mm Hg [6 Torr] or less. The unit should not be used if the gage reading is above 6 mm Hg [6 Torr].

6.1.3 Vacuum gage used for verification shall be verified for accuracy once every three years.

NOTE 5—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.

7. Sampling

7.1 Test specimens shall be molded from laboratory-prepared samples or taken from the pavement in the field. Obtain field samples in accordance with Practices D979/D979M and D5361/D5361M.

8. Test Specimen

8.1 It is recommended, (*1*) that the diameter of cylindrically molded or cored specimens, or the length of the sides of sawed specimens be at least equal to four times the maximum size of the aggregate; and (*2*) that the thickness of specimens be at least one and one-half times the maximum size of the aggregate. Pavement specimens are to be taken by such means as coring, sawing of blocks, and so forth.

8.2 Take care to avoid distortion, bending, or cracking of specimens during and after removal from pavement or mold. Store specimens in a safe, cool place.

8.3 Specimens shall be free of foreign materials such as sealcoat, tack coat, foundation material, soil, paper, or foil. When any of these materials is visually evident, it shall be removed. Sealcoat or tackcoat, or both, may be removed by sawing the bottom or the top faces, or both, of the sample.

8.4 If desired, separate specimens from other pavement layers by sawing or other suitable means.

8.5 Use a brush or a soft sanding block to break sharp edges around the top and bottom corners of the sample.

9. Procedure

9.1 Set the vacuum chamber to operate at a pressure of 6 mm Hg [6 Torr] for a minimum of 5 min.

9.2 *Mass of Unsealed Specimen:*

9.2.1 *Laboratory-Prepared Specimens*—Determine the mass of the specimen after it has cooled to room temperature. Designate this mass as *A*.

9.2.2 *Cores and Specimens Containing Moisture*—Dry the specimen to constant mass. Designate this mass as *A*. Constant mass is defined as less than 0.05 % change in mass between consecutive drying intervals.

NOTE 6—For accurate porosity determination, specimen should not be dried in the oven at temperatures above 30 °C [85 °F]. Oven drying will damage sample integrity. Vacuum drying method (Practice D7227/D7227M) for drying specimens is ideal for this test method.

9.3 *Mass of Sealed Specimen:*

9.3.1 Select an appropriate size bag. For all 100-mm [4-in.] diameter samples and samples with 150-mm [6-in.] diameter and less than 50-mm [2-in.] thickness, use the bag with smaller opening size as specified in 5.6. For 150-mm [6-in.] samples with greater than 50-mm [2-in.] thickness, use the larger opening size bags as specified in 5.6. For samples that weigh more than 5500 g [12.13 lb], use manufacturer's recommendation for appropriate bag size and configuration.

NOTE 7—Protect the bag during storage. Rough handling, storing in proximity to sharp objects such as tools, aggregate, or inside drawers will damage the plastic bag. Refer to manufacturer's recommendation for handling and safe storage.

9.3.2 Inspect the bag for holes or irregularities, record the mass of the bag and place the bag inside the vacuum chamber on top of the specimen sliding plate.

9.3.3 Gently open the bag and place the specimen in the plastic bag on top of the specimen sliding plate, being careful to handle the bag in such a manner that would prevent a puncture. Avoid dropping or impacting the bag, and follow manufacturer's recommendations for handling the specimens and the bags.

9.3.4 Allow the vacuum chamber to remove the air from the chamber and the plastic bag. The vacuum chamber shall automatically seal the bag after the vacuum operation has been completed.

9.3.5 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.

9.3.6 Remove the sealed sample from the vacuum chamber. Handle the sealed sample with extreme care to prevent puncturing the bag. Gently pull on the bag and if the bag easily separates from the sample, the bag may be punctured; repeat the sealing process with a new bag.

9.3.7 Determine the mass of the sealed specimen in air by summing mass *A* and the mass of the bag obtained in step 9.3.2. Designate this mass as *B*.

9.3.8 Place the sealed sample in the water bath equipped with a scale. Determine the mass of the sealed specimen in the water bath at 25 ± 1 °C [77 ± 2 °F]. Designate this mass as *E*. Make certain the sample is completely suspended in the water on top of the cushioned holder that is attached to scales. The bag shall not be floating out of the water and it shall not be touching the sides or the bottom of the water tank. Ensure that the temperature of water is set at 25 ± 1 °C [77 ± 2 °F].

9.3.9 With the sample and the bag completely submerged in water, use scissors to cut the bag open. This allows the water to rush into all water-accessible voids in the sample.

9.3.10 Allow the sample to remain underwater for at least 4 min. Record and designate this mass as *C*. The bag shall not be floating out of the water and it shall not be touching the sides or the bottom of the water tank.

10. Calculation

10.1 Calculate the bulk specific gravity of the sealed specimen as follows:

$$\text{Bulk Specific Gravity} = SG1 = \frac{A}{B - E - \frac{B - A}{F_T}} \quad (1)$$

where:

A = mass of dry specimen in air, g,
B = mass of dry, sealed specimen, g,
E = mass of sealed specimen underwater, g, and
F_T = apparent specific gravity of plastic sealing material at 25 ± 1 °C [77 ± 2 °F], when sealed, provided by the manufacturer.

10.2 Calculate the apparent specific gravity (gravity with the bag open) of the sample as follows:

$$\text{Apparent Specific Gravity} = SG2 = \frac{A}{B - C - \frac{B - A}{F_{T1}}} \quad (2)$$

C = mass of unsealed specimen underwater, g, and
F_{T1} = apparent specific gravity of plastic sealing material at 25 ± 1 °C [77 ± 2 °F] when opened under water, provided by the manufacturer.

$$\%\ \text{Porosity} = \%\ \text{Effective Air Voids} = \frac{SG2 - SG1}{SG2} \times 100 \quad (3)$$

11. Report

11.1 Report the following information:

11.1.1 Apparent specific gravities of plastic bags to four significant figures.

11.1.2 Bulk specific gravity of compacted sample at 25 ± 1 °C [77 ± 2 °F] to four significant figures.

11.1.3 Apparent specific gravity of compacted sample at 25 ± 1 °C [77 ± 2 °F] to four significant figures.

11.1.4 Effective porosity or percent effective air voids in percent to three significant figures.

12. Precision

12.1 The criteria for judging the acceptability of 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	0.35 %	1 %

The above estimate is based on 15 different asphalt mixes with different aggregate composition, gradation, binder type, and percent binder content. Six of the mixes were laboratory-compacted samples (four gyratory samples, two Marshall compactor samples) and nine were plant produced field samples. All tests were conducted by a single operator on the same vacuum sealing device. Each of the 15 samples was tested three times. Samples were fan dried between tests to surface dry condition; however, the original dry weight was used for the calculation of the gravities. The entire report is on file at ASTM headquarters.

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.

12.3 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. When more than two tests are being evaluated, the range given in Column 3 must be increased. Additional guidance and background are given in Practice E691.

12.4 The between-laboratory reproducibility of this test method is being determined and will be available on or before June 2018. Therefore, this standard should not be used for acceptance or rejection of a material for purchasing purposes.

12.5 No information can be presented on the bias of this procedure because no material having an accepted reference value is available.

13. Keywords

13.1 asphalt mixtures; bulk specific gravity; compacted samples; density; permeability; porosity

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