Designation: D 2726 – 00

# Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures[1]

This standard is issued under the fixed designation D 2726; 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 Department of Defense.*

## 1. Scope

1.1 This test method covers the determination of bulk specific gravity and density of specimens of compacted bituminous mixtures.

1.2 This test method should not be used with samples that contain open or interconnecting voids or absorb more than 2 % of water by volume, or both, as determined in 10.4.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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.*

## 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 1188 Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens[3]

D 1461 Test Method for Moisture or Volatile Distillates in Bituminous Paving Mixtures[3]

D 3203 Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures[3]

D 3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Bituminous Paving Materials[3]

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

## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *bulk density*—as determined by this test method, the mass of a metre cubed (or foot cubed) of the material at 25°C (77°F).

3.1.2 *bulk specific gravity*—as determined by this test method, the ratio of the mass of a given volume 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 The specimen is immersed in a water bath at 25°C (77°F). The mass under water is recorded, and the specimen is taken out of the water, blotted quickly with a damp cloth towel, and weighed in air. The difference between the two masses is used to measure the mass of an equal volume of water at 25°C. Correction factors are provided for converting the mass of water to that of the reference 25°C if from a practical point of view the weighing was done at different temperatures.

4.2 This test method provides guidance for determination of the oven dry or thoroughly dry mass of the specimen. The bulk specific gravity is calculated from these masses. Then the density is obtained by multiplying the specific gravity of the specimen by the density of the water.

## 5. Significance and Use

5.1 The results obtained from this test method can be used to determine the unit weight of compacted dense bituminous mixtures and in conjunction with Test Method D 3203, to obtain percent air voids. These values in turn may be used in determining the relative degree of compaction.

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[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.

5.2 Since specific gravity has no units, it must be converted to density in order to do calculations that require units. This conversion is made by multiplying the specific gravity at a given temperature by the density of water at the same temperature.

NOTE 1—The personnel and equipment used in performing this test can be evaluated in accordance with Practice D 3666.

## 6. Apparatus

6.1 *Balance*, with ample capacity, and with sufficient sensitivity to enable bulk specific gravities of the 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 suspended in water. To avoid erroneous readings by undue displacement of water, use wire or fish line of the smallest practical size to suspend the specimen and holder. Do not use chains, strings, or sash cords. 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 (bulk specific gravity) than appear in either the dividend (the mass of the specimen in air) or in the divisor (the mass of the volume of water equal to the volume of the specimen, obtained from the difference in weight of the saturated surface-dry specimen in air and in water), this means that the balance must have a sensitivity capable of providing both mass values to at least four figures. For example, a sensitivity of 0.1 g would provide four significant figures for mass in the range from 100.1 g to 999.9 g.

6.2 *Water Bath*, for immersing the specimen in water while suspended, equipped with an overflow outlet for maintaining a constant water level. The use of an overflow outlet is mandatory.

## 7. Sampling

7.1 Specimens may be either laboratory-molded bituminous mixtures or from bituminous pavements.

7.2 Obtain field samples in accordance with Practice D 979.

7.3 Pavement specimens shall be taken from pavements with a core drill, diamond or a carborundum saw, or by other suitable means.

## 8. Test Specimens

8.1 *Size of Specimens*—It is recommended, (*1*) that the diameter of cyclindrically 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.

8.2 Care shall be taken to avoid distortion, bending, or cracking of specimens during and after removal from pavements or mold. Specimens shall be stored in a safe, cool place.

8.3 Specimens shall be free of foreign materials such as seal coat, tack coat, foundation material, soil, paper, or foil. When any of these materials are visually evident, they shall be removed by sawing in accordance with 8.6.

8.4 If desired, specimens may be separated from other pavement layers by sawing or other satisfactory means.

## 9. Procedure

9.1 *For Cores and for Other Specimens that May Contain Moisture or Solvent*—Only specimens that are known to be thoroughly dry (that is, laboratory-prepared dried specimens), are to be tested in accordance with 9.2. All others are assumed to contain moisture or solvent and are to be tested in accordance with 9.1. The sequence of testing for 9.1 is: in water, saturated-surface dry, dry.

9.1.1 *Mass of Specimen in Water*—Completely submerge the specimen in the water bath at 25°C (77°F) for 3 to 5 min then determine the mass by weighing in water. Designate this mass as *C*. If the temperature of the specimen differs from the temperature of the water bath by more than 2°C (3.6°F), the specimen shall be immersed in the water bath for 10 to 15 min, instead of 3 to 5 min.

9.1.1.1 Measure the temperature of the water and if different from 25 ± 1°C (77 ± 1.8°F) a correction to the bulk specific gravity to 25°C must be made in accordance with 10.2.

9.1.2 *Mass of Saturated Surface-Dry Specimen in Air*—Surface dry the specimen by blotting quickly with a damp cloth towel and then determine the mass by weighing in air. Designate this mass as *B*.

9.1.3 After determining the mass in water and in a saturated-surface dry condition, thoroughly dry the specimen to a constant mass at 110 ± 5°C (230 ± 9°F). Allow the specimen to cool and weigh in air. Designate this mass as *A*. Other methods may be used to dry the specimen as long as a constant mass is achieved (mass repeats within 0.1 %).

NOTE 3—Drying the specimen at the required temperature of 110°C (230°F) will change the characteristics and shape of the specimen. This will make the specimen unsuitable for further testing. Drying the specimen at a reduced temperature such as 52°C (125°F), in order to keep it intact, will not meet the requirements of this test method.

9.1.3.1 Microwave drying or other approved methods may be used to dry the specimen if the specimen is not over-heated and documentation exists showing that the results are equivalent to oven drying. The interval of time between readings to determine constant mass must be sufficient to ensure that all moisture and solvent has been removed. This interval is dependent on the size of the specimen and can be determined by experimentation and confirmed with the oven-dried comparisons. Documentation must exist to validate the intervals.

9.2 *For Laboratory-Prepared Thoroughly Dry Specimens*:

9.2.1 *Mass of Dry Specimen in Air*—Determine the mass by weighing the specimen after it has been standing in air at room temperature for at least 1 h. Designate this mass as *A*.

9.2.2 *Mass of Specimen in Water*—Use the same procedure as described in 9.1.1.

9.2.3 *Mass of Saturated Surface-Dry Specimen in Air*—Surface dry the specimen by blotting quickly with a damp cloth towel and then determine the mass by weighing in air. Designate this mass as *B*.

## 10. Calculation

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

$$\text{Bulk sp gr} = A/(B - C) \quad (1)$$

where:

$A$ = mass of the dry specimen in air, g,

$(B - C)$ = mass of the volume of water for the volume of the specimen at 25°C,
$B$ = mass of the saturated surface-dry specimen in air, g, and
$C$ = mass of the specimen in water, g.

10.2 The bulk specific gravity of the specimen at 25°C can be calculated from bulk specific gravity of the specimen measured at any other temperature as follows:

$$\text{Bulk sp gr at 25°C} = K \times \text{Bulk sp gr measured at any other temperature} \quad (2)$$

where:
$K$ = determined from Table 1.

10.2.1 This calculation is valid for the precision of the test method if the temperature of the water differs from 25°C by less than 3°C (5.4°F). For a difference of temperature greater than 3°C (5.4°F), a correction to the mass of water displaced shall be made using the following equation:

$$\text{correction} = \Delta T \times K_s \times (B - C) \quad (3)$$

where:
$\Delta T$ = 25°C − the temperature of the water bath, and
$K_s$ = $6 \times 10^{-5}$ mL/mL/°C average coefficient of cubical thermal expansion of bituminous concrete.

10.3 Calculate the density of the specimen as follows:

$$\text{Density} = \text{Bulk sp gr} \times 997.0 \text{ ( or } 62.24) \quad (4)$$

where:
997.0 = density of water in $Kg/m^3$ at 25°C (0.9970 $g/cm^3$)

10.4 Calculate the percent water absorbed by the specimen (on volume basis) as follows:

$$\text{Percent water absorbed by volume} = \frac{B - A}{B - C} \times 100 \quad (5)$$

**TABLE 1 Absolute 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.

10.5 If the percent water absorbed by the specimen in 10.4 exceeds 2 %, use Test Method D 1188.

10.6 This test method has been written using the absolute system for density (kilograms per metre cubed) in SI units. The conversion to the gravitational system of unit weight in pounds per foot cubed and the recording of density in pounds force per foot cubed is acceptable with this test method.

## 11. Report

11.1 Report the following:

11.1.1 Bulk specific gravity of the mixture to the third decimal place as: bulk specific gravity at 25°C,

11.1.2 Density of the mixture with four significant figures in $Kg/m^3$ or $lb/ft^3$ as: density at 25°C,

11.1.3 Type of mixture,

11.1.4 Size of sample, and

11.1.5 Water absorption, %.

## 12. Precision and Bias

12.1 Criteria for judging the acceptability of bulk specific gravity test results obtained by this test method are given in the following table:[5]

| Test and Type Index | Standard Deviation (1S) | Acceptable Range of Two Results (D 2S) |
|---|---|---|
| Single operator precision | 0.0124 | 0.035 |
| Multilaboratory precision | 0.0269 | 0.076 |

NOTE 4—Samples for the interlaboratory study were prepared in three bituminous mixing plants and were compacted by the individual laboratories with Marshall compaction equipment using 75 blows each end of the specimen. Mechanical compactors were also used, but they were calibrated to give compaction equivalents for the 75 blows of the manual equipment.

In a report[6] dated March 22, 1988, The University of Nevada-Reno concluded that "The ASTM D2726 precision statement accurately reflects variances caused by either method of compaction (Marshall or Hveem), or by aggregate type (rounded or angular)."

12.2 The figures given in Column 2 are the standard deviations that have been found to be appropriate for the conditions of test described in Column 1. The figures given in Column 3 are the limits that should not be exceeded by the difference between the results of two properly conducted tests.

12.3 The values in Column 3 are the acceptable range for two tests. When more than two results are being evaluated, the range given in Column 3 must be increased. Multiply the standard deviation(s) in Column 2 by the multiplier given in Practice C 670, Table 1, for the number of actual tests. Example: for three tests − $0.0124 \times 3.3 = 0.041$. Additional guidance and background is given in Practice C 670.

12.4 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure for measuring density, no statement on the bias of this test method is being made.

## 13. Keywords

13.1 air voids; compaction; density; specific gravity; unit weight

[5] Basis of estimate: 4 replicates, 6 materials, 16 laboratories.

[6] Supporting data available from ASTM headquarters. Request RR: 1004.