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**Designation: ~~D2041/D2041M – 11~~ D2041/D2041M – 19**

# Standard Test Method for Theoretical Maximum Specific Gravity and Density of ~~Bituminous Paving~~ Asphalt Mixtures[1]

This standard is issued under the fixed designation D2041/D2041M; 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 the theoretical maximum specific gravity and density of uncompacted ~~bituminous paving~~ asphalt mixtures at ~~25°C [77°F].~~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 equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in ~~non-conformance~~nonconformance with the standard.

1.2.1 Residual pressure measurements are shown in both the SI unit of kPa and the commonly used ~~non-standard~~nonstandard equivalent unit of "mm of ~~Hg".~~Hg."

1.2.2 Measurements of volume and mass are only given in SI units because they are the only units typically used in practice when performing this test method.

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~~ safety, health, and ~~health~~environmental 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

D8 Terminology Relating to Materials for Roads and Pavements

~~D979~~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

~~E1~~D8055 ~~Specification for ASTM Liquid-in-Glass Thermometers~~Guide for Selecting an Appropriate Electronic Thermometer for Replacing Mercury Thermometers in D04 Road and Paving Standards

~~E12 Terminology Relating to Density and Specific Gravity of Solids, Liquids, and Gases (Withdrawn 1996)[3]~~

## 3. Terminology

3.1 ~~The terms "specific gravity"~~Refer to Terminology D8 ~~and "density" used in this test method are in accordance with Terminology~~ for definitions relating to materials for roads and pavements.~~E12.~~

3.2 *Definitions of Terms Specific to This Standard:*

[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~~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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3.2.1 *density, as determined by this test method*—the mass of a cubic meter of the material at ~~25°C [77°F]~~25 °C [77 °F] in SI units.

3.2.2 *residual pressure, as employed by this test method*—the pressure in a vacuum vessel 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]~~25 °C [77 °F] to the mass of an equal volume of water at the same temperature.

3.2.4 *standardize, as employed by this test method*—determine the value realized by a measurement instrument in direct comparison with the value realized by a standard under the same testing conditions.

## 4. Summary of Test Method

4.1 A weighed sample of oven-dry ~~paving~~asphalt mixture in the loose condition is placed in a tared vacuum vessel. Sufficient water at a temperature of ~~25°C [77°F]~~25 °C [77 °F] is added to completely submerge the sample. Vacuum is gradually applied to reduce the residual pressure in the vacuum vessel to 4 kPa [30 mm of Hg] or less and then held for 15 ± 2 min. At the end of the vacuum period, the vacuum is gradually released. The volume of the sample of ~~paving~~asphalt mixture is obtained by immersing the vacuum container with the sample in a water bath and weighing or by filling the vacuum container level full of water and weighing in air. Both the temperature and mass are measured at this time. From these mass and volume measurements, the specific gravity or density at ~~25°C~~25 °C [77 °F] is calculated.

## 5. Significance and Use

5.1 The theoretical maximum specific gravities and densities of ~~bituminous paving~~ asphalt mixtures are fundamental properties whose values are influenced by the composition of the mixture in terms of types and amounts of ~~aggregates and bituminous materials.~~aggregates, asphalt binder, and other materials present in the mixtures.

5.1.1 Maximum specific gravity is used (*1*) in the calculation of air voids in the compacted ~~bituminous paving~~ asphalt mixture, (*2*) in calculating the amount of ~~bitumen~~ asphalt binder absorbed by the aggregate, and (*3* ) to provide target values for the compaction of ~~paving~~asphalt mixtures.

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 ~~Standard Practice~~ Specification D3666 are generally considered capable of competent and objective ~~testing/sampling/inspection/etc.~~ testing, sampling, inspection, etc. Users of this standard are cautioned that compliance with ~~Practice~~Specification D3666 alone does not completely ~~assure~~ensure reliable results. Reliable results depend on many factors; following the suggestions of ~~Practice~~Specification D3666 or some similar acceptable guideline provides a means of evaluating and controlling some of those ~~factors~~factors.

## 6. Apparatus

6.1 *Containers:*

6.1.1 *Vacuum ~~Bowls—~~Bowl—*Either a metal or plastic bowl with a diameter of approximately 180 to 260 mm [7 to 10 in.] and a bowl height of at least 160 mm [6 in.] shall be equipped with a transparent cover fitted with a rubber gasket and a connection for the vacuum line. Both the bowl and cover should be sufficiently stiff to withstand the applied vacuum pressure without visibly deforming. The hose connection shall be covered with a small piece of fine wire mesh to minimize the loss of any fine material.

NOTE 2—The transparent cover allows observation of the release of air bubbles.

6.1.2 *Vacuum Flask for Weighing in Air ~~Only,~~ Only—*~~a~~A thick-walled volumetric glass flask with a capacity of approximately 4000 mL, fitted with a rubber stopper with a connection for the vacuum line. The hose connection in the flask should be covered with a small piece of fine wire mesh to minimize the loss of any fine ~~material~~material.

6.2 *Balance,* capable of being read to the nearest 0.1 g and conforming to the requirements of ~~Specification~~Guide D4753, Class GP2. If underwater measurements will be taken, then the balance shall be equipped with a suitable suspension apparatus and holder to permit weighing the sample while suspended from the center of the scale.

6.3 *Vacuum Pump or Water Aspirator,* capable of evacuating air from the vacuum container to a residual pressure of 4.0 kPa [30 mm of Hg] or less.

6.3.1 When a vacuum pump is used, a suitable trap shall be installed between the vacuum vessel and vacuum source to reduce the amount of water vapor entering the vacuum pump.

6.4 *Residual Pressure Manometer or Calibrated Absolute Pressure Gage*—This manometer or calibrated absolute pressure gage shall be used to confirm the specified pressure is applied to the container, and shall be capable of measuring residual pressure to 4.0 kPa [30 mm of Hg] or less. It is to be connected at the end of the vacuum line using an appropriate tube and either a "T" connector on the top of the container or by using a separate opening (from the vacuum line) in the top of the container to attach the hose. To avoid damage, the manometer or gage itself is not to be situated on top of the vessel but adjacent to it.

NOTE 3—Residual pressure in the vacuum vessel in millimeters of mercury is the difference in the height of mercury.

6.5 *Manometer or Vacuum Gage,* suitable for measuring the vacuum being applied at the source of the vacuum. This device can be connected directly to the vacuum source or be in the vacuum line close to the source.

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NOTE 4—The vacuum leg of a residual pressure manometer occasionally acquires one or more air bubbles that introduce error into the residual pressure reading. The additional vacuum gage or manometer provides a means to quickly detect differences between the two vacuum measurements.

6.6 ~~*Thermometers*—~~*Thermometer*—~~Calibrated liquid-in-glass thermometers~~Standardized immersion thermometer of suitable range ~~with subdivisions and maximum scale error of 0.5°C [1°F], conforming to the requirements of Specification~~ for this test method, with a readability of 0.1 °C [0.2 °F] and maximum permissible error of 0.5 °C [1 °F]. ~~E1 or any other thermometric device of equal accuracy, precision, and sensitivity shall be used.~~

NOTE 5—Guidance for selecting an appropriate electronic thermometer can be found in Guide D8055.

6.7 *Water Bath,* capable of maintaining, by any means, a constant temperature of 25 ± ~~1°C~~1 °C [77 ± ~~2°F~~].2 °F]. The water bath must be suitable for immersion of the suspended container with its deaerated sample.

6.8 *Bleeder Valve,* attached to the vacuum line to facilitate both the adjustment of the vacuum being applied to the vacuum vessel and the slow release of vacuum pressure. The valve can be controlled manually or electronically.

6.9 *Mechanical Agitation Device,* capable of applying a gentle but consistent agitation of the sample. This device shall be equipped with a means of firmly anchoring the container so that it does not move on the surface of the device.

NOTE 6—If stripping of asphalt is a problem, the device can be equipped with a speed control.

6.10 *Oven,* capable of maintaining a temperature of 110 ± ~~5°C~~5 °C [230 ± ~~10°F~~].10 °F]. This oven is needed when samples other than ~~laboratory-prepared~~ laboratory-prepared mixtures using oven-dry aggregate are tested.

## 7. Sampling

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

7.2 The size of sample shall be as follows:

| Nominal Maximum Aggregate Size, mm [in.] | Minimum Sample Size, g |
|---|---|
| ~~37.5 [1 ½] or greater~~ | ~~5000~~ |
| 37.5 [1½ ] or greater | 5000 |
| ~~19 to 25 [3/4 to 1]~~ | ~~2500~~ |
| 19 to 25 [¾ to 1] | 2500 |
| ~~12.5 [1/2] or smaller~~ | ~~1500~~ |
| 12.5 [½ ] or smaller | 1500 |

7.3 Sample sizes greater than about two thirds of the volume of the container shall be tested in portions, with none of the portions tested being less than 1250 g.

## 8. ~~Calibration of Containers~~ Determination of Water-Filled Container Mass

8.1 *Bowl (Weighing in Water)*—Immerse the bowl in water at 25 ± 1 °C [77 ± 2 °F]. Determine the mass of the bowl after readings have stabilized. Designate this mass as *B*.

8.2 ~~*Bowls*—~~*Bowl (Weighing in Air)*—~~Calibrate the container by accurately determining the mass of the container immersed~~ Immerse the bowl in water at 25 ± ~~1°C [77 ± 2°F]. Designate this~~ 1 °C [77 ± 2 °F]. Place the volumetric lid on the bowl while underwater. Remove the water-filled bowl with the lid in place and dry prior to determining the combined mass of the bowl, lid, and water. Repeat the entire process three times and average the results. Designate the average mass as ~~*B*.~~*D*.

~~8.1.1 If the bowl is used for weighing in air, place the volumetric lid on the bowl while under water. Remove the water-filled bowl with the lid in place and dry prior to determining the combined mass of the bowl, lid, and water. Repeat three times and average the results. Designate the average mass as *D*.~~

8.3 ~~*Flasks*—~~*Flask*—~~Calibrate the volumetric flask by accurately determining the~~ Determine the mass of the flask filled with water at a temperature of 25 ± ~~1°C~~1 °C [77 ± ~~2°F~~].2 °F]. Designate this mass as *D*. Accurate filling of the flask shall be ensured by the use of a glass cover plate or similar smooth, flat, transparent plate.

## 9. Procedure

9.1 If the ~~paving~~asphalt mixture has been prepared in a laboratory using oven-dry aggregates, proceed to 9.2. Any other sample needs to be dried to a constant mass (mass repeats within 0.1 % for consecutive ~~15 min~~ 15-min determinations) at a temperature of 110 ± ~~5°C [230± 10°F]~~.5 °C [230 ± 10 °F].

9.2 Once the sample is dry and while it is still warm, separate the particles of the sample of ~~paving~~asphalt mixture by hand, taking care to avoid fracturing the aggregate, so that the particles of the fine aggregate portion are not larger than about 6 mm ~~[1/4~~[¼ in.]. Cool the sample to room temperature. If separated particles adhere to each other once the sample has been cooled to room temperature, gently separate the particles of the fine aggregate portion so that they are not larger than about 6 mm ~~[1/4~~[¼ in.]. Place the sample directly into the tared bowl or volumetric flask. Do not use a container within a container. Weigh the container with the sample and designate the net mass (mass of sample only) as *A*.

9.3 Add sufficient water at a temperature of approximately ~~25°C [77°F]~~25 °C [77 °F] to cover the sample completely. Place the cover ~~(bowls)~~(bowl) or stopper (flask) on the container.

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