Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures

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5. Significance and Use

5.1 The theoretical maximum specific gravities and densities of asphalt mixtures are fundamental properties whose values are influenced by the composition of the mixture in terms of types and amounts of 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 asphalt mixture, (*2*) in calculating the amount of asphalt binder absorbed by the aggregate, and (*3*) to provide target values for the compaction of 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 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 *Containers:*

6.1.1 *Vacuum 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*—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.....

6.2 *Balance,* capable of being read to the nearest 0.1 g and conforming to the requirements of 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.

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 *Thermometer*—Standardized immersion thermometer of suitable range for this test method, with a readability of 0.1 °C [0.2 °F] and maximum permissible error of 0.5 °C [1 °F] .

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 [77 ± 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 [230 ± 10 °F]. This oven is needed when samples other than laboratory-prepared mixtures using oven-dry aggregate are tested.

7. Sampling

7.1 Obtain the sample in accordance with Practice 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 1⁄2] or greater	5000
19 to 25 [3⁄4 to 1]	2500
12.5 [1⁄2] 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.

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8. 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 *Bowl (Weighing in Air)*—Immerse the bowl in water at 25 ± 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 *D*..

8.3 *Flask*—Determine the mass of the flask filled with water at a temperature of 25 ± 1 °C [77 ± 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 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 determinations) at a temperature of 110 ± 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 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 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 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] to cover the sample completely.....

Place the cover (bowl) or stopper (flask) on the container.....

9.4 Place the container with the sample and water on a mechanical agitation device and anchor it to the surface of the device.....

Start the agitation and immediately begin to remove air trapped in the sample by gradually increasing the vacuum pressure until the residual pressure manometer reads 3.7 ± 0.3 kPa [27.5 ± 2.5 mm of Hg] .....

The vacuum should be achieved within 2 min.....

Once the vacuum is achieved, continue the vacuum and agitation for 15 ± 2 min.....

9.5 Gradually release the vacuum pressure using the bleeder valve and proceed with one of the following determinations: .....

9.5.1 *Weighing in Water*—Suspend the bowl (without lid) and contents in water for 10 ± 1 min, then determine the mass.....

Measure and record the temperature of the water in the bath.....

Designate the mass under water of the bowl and sample as *C*.....

9.5.2 *Weighing in Air (Bowl)*—Slowly submerge the bowl and sample in the 25 ± 1 °C [77 ± 2 °F] bath, where it shall remain for 10 ± 1 min.....
The lid shall also be placed in the water bath at the same time.....
Slide the lid onto the bowl without removing from the water so as to avoid entrapping any air, then firmly press the lid down on the bowl.....
Remove the bowl with the lid in place from the water bath.....
Carefully dry the bowl and lid.....
Determine the mass of the bowl, sample, and lid.....
Measure and record the temperature of the water in the bowl.....
Repeat this procedure a second time by removing the lid and placing both the lid and the bowl back in the water.....
It is not necessary to wait the 10 min before taking the second reading.....
If the mass varies by more than 1.0 g, repeat the procedure until any two mass readings are within 1.0 g.....
Designate the average mass of these two readings as "*E*; the mass of the bowl, lid, water, and sample." .....
9.5.3 *Weighing in Air (Flask)*—Slowly fill the flask with water, taking care not to introduce air into the sample.....
Place the flask in a water bath for 10 ± 1 min to stabilize the temperature without submerging the top of the flask.....
Measure and record the temperature of the water in the flask.....
Remove the thermometer and completely fill the flask using a cover plate, taking care not to entrap air beneath the cover plate.....
The cover plate shall be the same one used during the calibration of the flask.....
Wipe any moisture from the exterior of the container and cover plate.....
Determine the mass of the flask, plate, and its contents completely filled with water. Designate this mass as *E*.....

10. Calculation

10.1 Calculate the maximum specific gravity of the sample as follows:
10.1.1 *Bowl Used in Underwater Determination:* .....

$$Gmm = \frac{A}{A - (C - B)} \quad (1)$$

where:
Gmm = maximum specific gravity of the asphalt mixture,
A = mass of dry sample in air, g,
B = mass of bowl under water, g, and
C = mass of bowl and sample under water, g.

10.1.2 *Bowl in Air Determination:* .....

$$Gmm = \frac{A}{A + D - E} \quad (2)$$

where:
Gmm = maximum specific gravity of the asphalt mixture,
A = mass of dry sample in air, g,
D = mass of lid and bowl with water at 25 °C [77 °F], g, and
E = mass of lid, bowl, sample, and water at 25 °C [77 °F], g.

10.1.3 *Flask Determination:* .....

$$Gmm = \frac{A}{A + D - E} \quad (3)$$

where:
Gmm = maximum specific gravity of the asphalt mixture,
A = mass of dry sample in air, g,
D = mass of cover plate and flask filled with water at 25 °C [77 °F], g, and
E = mass of flask, cover plate, sample, and water at 25 °C [77 °F], g.

10.2 If the sample was tested in several portions, report the weighted average maximum specific gravity for all portions tested.....

11. Supplemental Procedure for Asphalt Mixtures Containing Porous Aggregate

11.1 If the pores of the aggregates are not thoroughly sealed by the asphalt binder film, they may become saturated with water during the vacuum procedure. To determine if this has occurred, proceed as follows after completing the procedure in accordance with 9.5.1, 9.5.2, or 9.5.3.....
11.1.1 Drain the water from the container. To prevent the loss of fine particles, decant the water through a 75-µm [No. 200] sieve.....
11.1.2 Break several of the large pieces of aggregate and examine the broken surfaces for wetness
If there is any doubt as to whether the asphalt mixture has absorbed water, proceed with this procedure in order to determine if this correction is needed.....
11.2 If aggregate has absorbed water, spread the sample on a flat tray with a nonabsorptive surface and place in front of a fan to remove surface moisture.....
Break agglomerations of mixture by hand.....
Stir the sample intermittently in such a way that the aggregate particles are rolled over rather than simply moved horizontally on the tray.....
This process takes about 2 h. Take care to prevent the loss of particles of mixture. .....
11.3 Weigh the tray and sample at 15-min intervals.....
When the loss in mass is less than 0.05 % for this interval, the sample may be considered to be surface dry.....
11.4 Substitute the final surface dry mass for *A* and use this value in the denominator of equations shown in Section 10.....

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12. Report

12.1 Report the following information:

12.1.1 Maximum specific gravity, *Gmm*, to the third decimal place....._____

12.1.2 Type of asphalt mixture....._____

12.1.3 Size of sample....._____

12.1.4 Number of samples....._____

12.1.5 Type of container....._____

12.1.6 Type of procedure....._____

Comments