5.16.39 THEORETICAL MAXIMUM SPECIFIC GRAVITY OF ASPHALT PAVING MIXTURES (Kansas Test Method KT-39)

a. SCOPE

This method covers the determination of the theoretical maximum specific gravity of uncompacted asphalt paving mixtures. **KT-39** reflects testing procedures found in AASHTO T 209.

b. REFERENCED DOCUMENTS

b.1. KT-58; Method for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

b.2. AASHTO M 231; Weighing Devices Used in the Testing of Materials

b.3. AASHTO T 209; Maximum Specific Gravity of Bituminous Paving Mixtures

b.4. ASTM E 1; Specifications for ASTM Thermometers

c. APPARATUS

c.1. Vacuum Container:

c.1.a. Six different vacuum containers are described. Each must be capable of withstanding the full vacuum applied, and each must be equipped with the fittings and other accessories required by the test procedure being employed. The hose opening shall be covered with a small piece of 75 µm wire mesh to prevent vacuum pickup of particles during transfer of materials.

c.1.b. The vacuum container size depends on the minimum sample size requirements given in Section **e.1.** Avoid using a small sample in a large container.

c.1.c. Vacuum containers for weighing in air and water.

c.1.c.1. Type A: A glass, plastic, or metal bowl with a capacity of approximately 2000 mL.

c.1.c.2. Type B: A thick-wall filter flask or a thick-wall vacuum dessicator with a capacity of approximately 2000 mL.

c.1.d. Vacuum containers for weighing in air only.

c.1.d.1. Type C: A small volumetric flask with a capacity of approximately 2000 mL.

c.1.d.2. Type D: An intermediate-size heavy-wall glass pycnometer with a capacity of approximately 4000 mL.

c.1.d.3. Type E: A 4500 mL metal vacuum pycnometer with a clear poly- (methyl methacrylate) (PMMA) lid.

c.1.d.4. Type F: A large size plastic pycnometer[a] having a capacity of at least 10,000 mL.

NOTE a: A polycarbonate plastic has been found to be a suitable material when properly fabricated for the large size plastic pycnometer (Type F). Tests have shown it to be safe for use under essentially full vacuum over a temperature range from 59 to 175°F (15 to 80°C).

c.2. The balance shall conform to the requirements of AASHTO M 231 for the class of general-purpose balance required for the principal sample mass of the sample being tested. The balance shall be readable to 0.1 percent or better of the sample mass. For the bowl determination method 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 pan of the balance.

c.3. Vacuum pump or water aspirator capable of evacuating air from the container to a residual pressure of 27 mm of Hg [3.7 kPa].

c.3.a. When a vacuum pump is used, a suitable trap of one or more 1000 mL filter flasks, or the equivalent, shall be installed between the vacuum vessel and vacuum source to reduce the amount of water vapor entering the vacuum pump.

c.4. Residual pressure manometer[b&c], or vacuum gauge traceable to NIST (mandatory) to be connected directly to the vacuum vessel and to be capable of measuring residual pressure down to 27 mm Hg [3.7 kPa].

NOTE b: A residual pressure of 30 mm Hg [4.0 kPa] absolute pressure is approximately equivalent to 730 mm Hg [97 kPa] reading on vacuum gauge at sea level.

NOTE c: Residual pressure in the vacuum vessel measured in millimeters of mercury, is the difference in the height of mercury in the Torricellian vacuum leg of the manometer and the height of mercury in the other leg of the manometer that is attached to the vacuum vessel.

c.5. Manometer or vacuum gauge, 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. This is required to check the reading given by the residual pressure manometer attached directly to the vacuum vessel.

NOTE d: The Torricellian vacuum leg of the manometer occasionally acquires one or more bubbles of air that introduce error into the residual pressure reading. By the addition of the vacuum gage this error can often be quickly detected by the differences between the two vacuum measurements.

c.6. Thermometers: Calibrated liquid-in-glass, total immersion type, of suitable range with graduations at least every 0.2°F (0.1°C) and a maximum scale error of 0.9°F (0.5°C) as prescribed in ASTM E 1.

c.7. A draft oven capable of maintaining a uniform temperature of 275 ± 9°F (135 ± 5°C).
c.8. Water Bath. For use with the bowl, a water bath suitable for immersing the bowl in water while suspended under the balance and equipped with an overflow outlet for maintaining a constant water level. For use with the flask, a constant-temperature water bath maintained at 77 ± 2°F (25 ± 1°C).

c.9. Bleeder valve, attached to the vacuum train to facilitate adjustment of the vacuum being applied to the vacuum vessel.

c.10. Plexiglass top used to calibrate and establish when a pycnometer or any other large-mouth container is full of water. The plexiglass top shall be large enough to cover the container and overlap at least 1 in (25 mm) with a minimum of 1/2 in (12.5 mm) thick.

c.11. Mechanical Shaker: Shaker for removing air from asphalt mix with a built-in digital timer capable of 0.25 second accuracy and a maximum time limit of 99 minutes. Also must have ability to adjust vibration frequency to permit maximum release of air and a 3-position switch for off, manual or timed operation. Must have the ability to fully clamp and hold in place a metal pycnometer full of water and asphalt mix while removing the air from the mix through the vibration process. Must be able to meet or exceed the Gilson Vibro-Deairator (SGA-5R).

d. CALIBRATION OF FLASKS, BOWLS, AND PYCNOMETERS

d.1. For the weighing-in-water method (Section **f.5.a.**), the mass of the Type A or Type B vacuum containers shall be calibrated in water while the water is maintained at 77 ± 2°F (25 ± 1°C)[1].

d.2. For the weighing-in-air method (Section **f.5.b.**), calibrate the Types C, D, E, or F containers by determining the mass of the container when filled with water at 77 ± 2°F (25 ± 1°C). Designate this mass as "D". Accurate filling shall be ensured by the use of a plexiglass cover plate.

d.2.a. Fill the container to the point of overflowing. Place the plexiglass plate over 1/3 of the top and begin sliding the plate to cover the entire top of the container. If any air bubbles are visible, back up and remove. Once the plate fully covers the top, and all air bubbles are removed, wipe off excess water on sides and determine the mass.

d.3. The following filling procedure may be used for the model with latched lid and vented stopper. The domed lid is latched in place and the pycnometer (Type F) nearly filled with water. Leave about 2 in (50 mm) empty. The release of air bubbles may be facilitated by applying vacuum and by jarring(dropping first one side then the other of the pycnometer (Type F) about ½ in (10 mm) on the bench surface). This vacuum application and bubble release procedure should take about 10 min so that the temperature equilibrium between the shell and the water approximates that attained when running a test. The final water is then gently poured in until the level is about one half up into the neck. Any air bubbles caught against the dome that cannot be released by jarring or by swirling the water may be "pricked" or pushed to the surface with a bent wire. Insert the vented stopper using only enough force to just seat the stopper and immediately wipe the excess water off the top.

d.4. While calibration of the flask, Type F, or of either pycnometer (Types D or E), need to be done only once, the calibration should be checked weekly at 77°F (25°C). Recalibration is required if a change in water source takes place. The equipment must be kept clean and free from any accumulation that changes the mass if the volume calibration is to remain constant. Care should be taken to use only natural solvents, especially with plastic containers while glass vessels should not be subjected to high vacuum if they are scratched or damaged.

e. PREPARING MATERIAL

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[1] AASHTO T 209 calibrates for a range of temperatures. KDOT specifies the water bath be maintained at 77 ± 2°F (25 ± 1°C). This requirement is to maintain the density of water to a single density number as outlined in **g.2.a.**

e.1. Sample Size: The size of the sample shall conform to the requirements of Table **5.16.39-01**. Samples larger than the capacity of the container may be tested a portion at a time.

Table 5.16.39-01: Test Sample Size

Maximum Aggregate Size in Mixture	Minimum Sample Size, g
2 in (50.0 mm)	6,000
1 1/2 in (37.5 mm)	4,000
1 in (25.0 mm)	2,500
3/4 in (19.0 mm)	2,000
1/2 in (12.5 mm)	1,500
3/8 in (9.5 mm)	1,000
No. 4 (4.75 mm)	500

f. PROCEDURE

f.1. If this is a design mix, then age the asphalt material by placing the sample in a preheated draft oven at compaction temperature for 2 hours[e] as outlined in **KT-58 h.5.** Remove from the oven and permit to cool. During the cooling process, start separating the particles. Once the sample nears room temperature, separate the particles of the sample by hand, taking care to avoid fracturing the aggregate, so that the particles of the line aggregate portion are not larger than ¼ in (6.3 mm). If the sample 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.
NOTE e: Field samples should be retrieved from the road way behind the paver, stored in an insulated container and returned to the laboratory. Once the sample arrives at the laboratory and the material is hot enough to separate out as outlined in **f.1.**, then continue with **f.2.** If the sample has cooled too much, then place in a preheated draft oven at compaction temperature for 30 minutes and continue with **f.2.** Do not perform the aging process as stated in **f.1.**

f.2. Unless the sample has been prepared in a laboratory using oven-dry aggregates, oven-dry to constant mass at a temperature of 221 ± 9°F (105 ± 5°C). This drying and any required warming for particle separation as described in Section **f.1.** should be combined as a single operation to minimize reheating effects. Any Marshall or Superpave Gyratory plugs used must also be dried and softened in an oven (30 -60 minutes).

f.3. Cool the sample to room temperature, place it in a tared calibrated flask, bowl, or pycnometer. The sample is to be placed directly into type A, B, C, D, or E vacuum container. A container within a container is not to be used. Weigh and designate the net mass of the sample as "A". Add sufficient water at a temperature of 77 ± 2°F (25 ± 1°C) to cover the sample completely.

f.4. Remove air trapped in the sample by applying gradually increased vacuum until the residual pressure manometer reads 27 ± 3 mm of Hg [3.7 ± 0.3 kPa]. Full vacuum shall be applied within 30 seconds. Maintain this residual pressure for 14 ± 0.5 min. Agitate the container and contents during the vacuum period continuously using a mechanical device. Glass vessels should be shaken on a resilient surface such as a rubber or plastic mat, and not on a hard surface, so as to avoid excessive impact while under vacuum.

f.4.a. The frequency on the mechanical shaker shall be set to impart a vibration that maximizes particle turbulence without rotating the material in a clockwise or counterclockwise direction.

NOTE f: The release of entrapped air may be facilitated by the addition of a suitable wetting agent such as Aerosol OT in concentration of 0.001 percent or 0.2 grams on 20 L of water. This solution is then diluted by about 20 mL to make a wetting agent of which 5 to 10 mL may be added to the apparatus.

f.5. At the end of the vacuum period, release the vacuum by increasing the pressure at a rate not to exceed 60 mm of Hg [8 kPa] per second and proceed with one of the following determinations.

f.5.a. Weighing in water: Suspend the container and contents in the water bath and determine the mass after 10 ± 1 minute immersion. Measure the temperature of the water bath to verify 77 ± 2°F (25 ± 1°C). Designate the mass of the sample in water as "C".

f.5.b. Weighing in air: Fill the flask (Type C), or any one of the pycnometers (Type D, E, or F) with water. Determine the mass of the container (and contents), completely filled, in accordance with Section **d.2.** and **d.2.a.** within 10 ± 1 minute after completing section **f.4.** Verify and adjust the temperature to be at 77 ± 2°F (25 ± 1°C) prior to taking the reading. Designate this mass as "E".

g. CALCULATIONS

g.1. Calculate the theoretical maximum specific gravity (G_{mm}) of the sample at 77°F (25°C) as follows:

g.1.a. Weighing in water:

$$G_{mm} = A/(A-C)$$

Where:

A = mass of dry sample in air, g, and
C = mass of water displaced by sample at 77°F (25°C), g,

g.1.b. Weighing in air:

$$G_{mm} = A/(A+D-E)$$

Where:

A = mass of dry sample in air, g.
D = mass of container filled with water at 77°F (25°C), g, and
E = mass of container filled with sample and water at 77°F (25°C), g.

g.1.c. When it is necessary to test a sample a portion at a time, the differences between the theoretical maximum specific gravities for each portion should be within the precision statements listed in Section **h.** If the values are within the precision statements, the specific gravities for each portion shall be averaged. If the values are outside the precision statements, the test shall be run again.

g.2. Calculate the theoretical maximum specific gravity of the samples as shown on the work sheet below.

THEORETICAL MAXIMUM SPECIFIC GRAVITY OF
ASPHALT PAVING MIXTURES

Reference:

Project _____ Date _____ Lab.No. _____				
Sample No. Mass of Container, g				
Mass of Dry Sample in air, g	A			
Mass of Vacuumed Sample in Water, g	C			
Mass of Filled Container with Water at 77ºF (25ºC), g	D			
Mass of Filled Container with Water And Vacuumed Sample at 77ºF (25ºC), g	E			
Specific Gravity (in water) = A/(A-C)				
Specific Gravity (in air) = A/(A + D – E)				

h. PRECISION

h.1. Criteria for judging the acceptability of specific gravity test results obtained by this method are given in **Table 5.16.39-1.** 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 the two properly conducted tests.

TABLE 5.16.39-1[2]
SPECIFIC GRAVITY TEST RESULTS

Type[3]	Standard Deviation (1S)	Acceptable Range of Two Results (D2S)
Single-operator precision	0.0040	0.011
Multilaboratory precision	0.0064	0.019

[2] Table 5.16.39-1 is copied from AASHTO T 209 **.**

[3] AASHTO T 209 provides an additional section, **8. SUPPLEMENTAL PROCEDURE FOR MIXTURES CONTAINING POROUS AGGREGATE NOT COMPLETELY COATED.** This section is not addressed in KT-39.