Designation: D6925 – 23

Standard Test Method for Preparation and Determination of the Relative Density of Asphalt Mix Specimens by Means of the Superpave Gyratory Compactor[1]

This standard is issued under the fixed designation D6925; 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 compaction of an asphalt mix into cylindrical specimens using the Superpave Gyratory Compactor (SGC). This standard also refers to the determination of the relative density of the compacted specimens at any point in the compaction process. Compacted specimens are suitable for volumetric, physical property, and mechanical testing. Smaller specimens may be cut from the compacted cylindrical specimen for specific test specimen geometry requirements. The compaction procedures apply to Laboratory Mixed Laboratory Compacted (LMLC) and Plant Mixed Laboratory Compacted (PMLC) asphalt mix.

1.2 The values stated in SI units are to be regarded as standard. The values given in degrees for the angle of gyration, gyrations per minute, and hardness are mathematical conversions from the SI units and are provided for information regarding the commonly used units of degree, rotations per minute, and Rockwell hardness, respectfully.

1.3 The text of this test method 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, health, and 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]

D8 Terminology Relating to Materials for Roads and Pavements

D979/D979M Practice for Sampling Asphalt Mixtures

D1188/D1188M Test Method for Bulk Specific Gravity and Density of Compacted Asphalt Mixtures Using Coated Samples

D2041/D2041M Test Method for Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures

D2726/D2726M Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Asphalt Mixtures

D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials

D4402/D4402M Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

D6752/D6752M Test Method for Bulk Specific Gravity and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method

D6857/D6857M Test Method for Maximum Specific Gravity and Density of Asphalt Mixtures Using Automatic Vacuum Sealing Method

D7115 Test Method for Measurement of Superpave Gyratory Compactor (SGC) Internal Angle of Gyration Using Simulated Loading

E10 Test Method for Brinell Hardness of Metallic Materials

E18 Test Methods for Rockwell Hardness of Metallic Materials

E2251 Specification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids

[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.20 on Mechanical Tests of Asphalt Mixtures.

Current edition approved Dec. 1, 2023. Published January 2024. Originally approved in 2003. Last previous edition approved in 2015 as D6925 – 15. DOI: 10.1520/D6925-23.

[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.

2.2 *AASHTO Standards:*[3]

R 18 Standard Practice for Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories

R 99 Standard Practice for Troubleshooting Asphalt Specimen Volumetric Differences between Superpave Gyratory Compactors (SGCs) Used in the Design and the Field Management of Superpave Mixtures

R 30 Standard Practice for Mixture Conditioning of Hot Mix Asphalt (HMA)

R 35 Standard Practice for Superpave Volumetric Design for Hot Mix Asphalt (HMA)

R 47 Standard Practice for Reducing Samples of Hot Mix Asphalt (HMA) to Testing Size

T 312 Standard Method of Test for Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

T 344 Standard Method of Test for Evaluation of Superpave Gyratory Compactor (SGC) Internal Angle of Gyration Using Simulated Loading

2.3 *Other References:*

ASME B46.1 Surface Texture (Surface Roughness, Waviness, and Lay)[4]

Asphalt Institute MS-2 Mix Design Methods for Asphalt Concrete[5]

3. Terminology

3.1 This test method uses terms as defined by Terminology D8.

4. Significance and Use

4.1 This test method is used to prepare specimens for determining the volumetric and physical properties of compacted asphalt mix.

4.2 This test method is useful for monitoring the density of test specimens during the compaction process. This test method is suited for the laboratory design, field control of asphalt mix, forensics, imaging, and visualization of compacted asphalt mix.

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.

5. Apparatus

5.1 *Superpave Gyratory Compactor*—A compactor comprised of the following system components: (*1*) reaction frame and drive system, (*2*) loading system, loading ram, and pressure indicator, and (*3*) recording system for height measurement and number of gyrations.

5.1.1 The reaction frame shall provide a structure against which the compaction pressure can be applied when compacting specimens.

5.1.2 The compactor shall be designed to gyrate the mold at a constant angle of gyration during the compaction process. An internal angle of gyration of 20.25 ± 0.35 mrad (1.16 ± 0.02°) as determined by Test Method D7115 shall be utilized.

NOTE 2—Research has shown external angle (measurement between the external mold wall and the frame of the compactor) to be different from the internal angle (measurement between internal mold wall and top and bottom plate). The difference between these measurements varies for different types of compactors. Some discrepancies in relative density have been resolved by use of the internal angle.

5.1.3 The gyration drive system shall be capable of gyrating the specimen at a rate of 0.5 ± 0.0083 Hz (30.0 ± 0.5 gyrations per minute).

5.1.4 The loading system, ram, and force indicator shall be capable of providing and measuring a constant vertical force to provide an applied pressure of 600 ± 60 kPa during the first five gyrations and 600 ± 18 kPa during the remainder of the compaction process. The applied pressure is defined as the applied force divided by the area of the nominal mold diameter (150 mm).

NOTE 3—The report on the ruggedness evaluation of AASHTO TP4 (T 312)[6] indicated that the pressure tolerance of ±18 kPa resulted in significantly different values of bulk specific gravity of the compacted specimens (G_{mb}) in some cases. However, since the pressure is directly set at 600 kPa, the tolerance of ±18 kPa should apply only to the ability of the SGC to maintain vertical pressure during compaction. To minimize potential errors caused by pressure, operators should take care during verification of calibration to ensure that the specified pressure has been attained.

5.1.5 The axis of the loading ram shall be perpendicular to the platens of the compactor.

5.1.6 The height measurement and recording system shall be capable of continuously measuring and recording the height of the specimen during the compaction process to the nearest 0.1 mm. The height shall be recorded once per gyration.

5.1.7 The system shall record test information such as specimen heights per gyration. This may be accomplished through data acquisition or printing.

5.1.8 The system shall be capable of stopping at a specified number of gyrations or at a specified height through automatic control or operator input.

5.2 *Specimen Molds*—Specimen molds shall have steel walls that are at least 7.5 mm thick and are hardened to Rockwell C48 or better. New molds shall have an inside diameter of 149.90 mm to 150.00 mm. The inside diameter of molds in service shall be 149.90 to 150.20 mm. The inside

[3] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.

[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

[5] Available from Asphalt Institute, 2696 Research Park Dr., Lexington, KY 40511, http://www.asphaltinstitute.org.

[6] McGennis, R., Kennedy, T. W., Anderson, V. L., Perdomo, D., "The Superpave Gyratory Compactor," *Journal of the Association of Asphalt Paving Technologists*, Vol 66, 1997, pp. 277–311.

finish of the molds shall be smooth (rms of 1.60 µm or smoother when measured in accordance with ASME B46.1). The inside diameter of the molds shall be measured in accordance with Annex A1.

5.3 *Mold Plates and Ram Heads*—All mold plates and ram heads in contact with the mixture shall be fabricated from steel with a minimum hardness of 451 BHN according to Test Method E10 (Rockwell Hardness of C48 according to Test Method E18). The mold plates and ram head surfaces in contact with the mixture shall be flat and shall have an outside diameter of 149.50 to 149.75 mm. The outside diameter of the end plates shall be measured in accordance with Annex A1.

5.4 *Thermometers*—Calibrated liquid-in-glass thermometers of suitable range with subdivisions of 0.1 °C or 0.2 °C conforming to the requirements of Specification E2251 shall be used (ASTM Thermometer Numbers S67F-03 or S67C-03; S65F-03 or S65C-03; S63F-03 or S63C-03; or equivalent). Alternatively, other thermometer may be used, for example resistance thermometer (RTD, PRT, IPRT) of equal or better accuracy. Calibrate the temperature measurement system (probe and readout) to ensure accurate measurements within ±3 °C.

NOTE 4—Standardization practices specified in Specification D3666 are recommended for the thermometer used in this test method. Dial thermometers may exhibit inaccuracies due to frequent use or mishandling. It is recommended that the standardization of dial thermometers be conducted more frequently by a comparison to a reference thermometric device of equal or greater readability at a temperature within the range of intended use.

5.5 *Balance*—The balance shall have a minimum capacity of 10 000 g with a sensitivity of 0.1 g. The balance shall conform to Guide D4753 as a Class GP2 balance.

5.6 *Oven*—A forced-draft oven capable of maintaining the specimen at the required temperature for heating aggregate, asphalt, and equipment. The oven shall have a range of 50 °C to a minimum of 204 °C, thermostatically controlled to ±3 °C.

5.7 *Miscellaneous*—Miscellaneous equipment may include: flat bottom metal pans for heating aggregates; scoops for batching aggregates; containers for heating asphalt binders; mixing spoons; trowels; spatulas; welder's gloves for handling hot equipment; 150 mm paper disks; lubricants for moving parts; laboratory timers; and mechanical mixers.

6. Standardization

6.1 Items requiring periodic standardization of calibration include the vertical pressure, internal angle of gyration, frequency of gyration, height measurement system, and oven temperature. Check of the mold and platen dimensions and smoothness of finish is also required. Verification of calibration, system standardization, and quality checks shall be performed by the manufacturer, other agencies providing standardization services, or in-house personnel. Frequency of verification shall follow Specification D3666 intervals.

6.2 Standardize the internal angle of gyration, pressure (applied force (kN) divided by nominal mold area (m^2)), height measurement, and gyration speed annually and whenever there is reason to doubt the stability of the machine's operation. Check the mold bore diameter and end plate diameters annually.

6.3 Verification of standardization shall be performed if the gyratory compactor is transported to a new location.

NOTE 5—Unknown SGC equipment should be evaluated using procedures such as Test Method D7115 to assess its ability to produce compacted specimens at various compaction levels which are equivalent to existing SGC models which are known to have met the specifications. Such assessments should utilize the calibration and operational parameters outlined in Section 5.

7. Preparation of Lab Mixed Lab Compacted (LMLC) Test Specimens

7.1 *Preparation of Aggregates*—Weigh and combine the appropriate aggregate fractions to the desired specimen weight. The specimen weight will vary based on the ultimate disposition of the test specimens. If a target air void level is desired such as that required for mechanical property tests, specimen weights shall be adjusted to create a given density in a known volume. If the specimens are to be used for determination of volumetric properties, the weights shall be adjusted to result in a compacted specimen having dimensions of 150 mm in diameter and 115 ± 5 mm in height at the required number of gyrations.

NOTE 6—It may be necessary to produce a trial specimen to achieve this height requirement. Generally, 4500 to 4700 g of aggregate are required to achieve this height for aggregates with combined bulk specific gravities of 2.55 to 2.70 respectively.

NOTE 7—Details of aggregate preparation may be found in any suitable mix design manual, such as the Asphalt Institute's MS-2 or AASHTO R 35.

7.2 Place the blended aggregate specimens and asphalt binder in an oven and bring to the required mixing temperature. Heat the mixing container and all necessary mixing implements to the required temperature.

7.2.1 The laboratory mixing temperature range is typically defined as the range of temperatures where the unaged asphalt binder has a viscosity of 170 ± 20 mPa·s measured in accordance with Test Method D4402/D4402M.

NOTE 8—Modified asphalt binders, especially those produced with polymer additives, generally do not adhere to the equiviscous ranges noted in 7.2.1. The user should refer to the asphalt binder manufacturer to establish appropriate mixing and compaction temperature ranges. In no case should the mixing temperature exceed 175 °C.

7.3 Charge the heated mixing bowl with the dry, heated aggregate and mix the dry aggregates. Form a crater in the heated aggregate blend and weigh the required amount of asphalt binder into the aggregate blend. Immediately initiate mixing.

7.4 Mix the asphalt binder and aggregate as quickly and thoroughly as possible to yield an asphalt mixture having a uniform distribution of asphalt binder. Because of the large batch weights, a mechanical mixer is preferable for the mixing process.

7.5 After completing the mixing process, subject the loose mix to the appropriate conditioning in accordance with AASHTO R 30.

NOTE 9—Different asphalt mix conditioning procedures may apply for volumetric design and mechanical property testing specimens.

8. Preparation of Plant Mixed Lab Compacted (PMLC) Test Specimens

8.1 Samples of plant-produced asphalt mix shall be obtained according to Practice D979/D979M or other specified sampling method. Samples shall be reduced to test size according to AASHTO R 47 or other specified procedure.

8.2 For samples of plant-produced asphalt mix, the user must specify one of the following short-term aging conditions.

8.2.1 No conditioning, compact immediately as produced. The asphalt mix may need to be equilibrated at lab compaction temperature as defined in 9.1.1.

8.2.2 Condition according to 7.5.

8.2.3 Another conditioning that the user can demonstrate will replicate the design conditioning.

NOTE 10—Reheated Plant Mixed Lab Compacted (RPMLC) asphalt mix reheating procedures may induce artificial aging which may influence compacted density.

9. Compaction Procedure

9.1 Place a compaction mold assembly (including mold and end plates) in an oven at the required compaction temperature ± 5 °C for a minimum of 45 min prior to the compaction of the first mixture specimen (during the time the mixture is in the conditioning process described in 7.5).

NOTE 11—Oven performance and temperature uniformity can significantly impact the time required for a mold to reach compaction temperature. Mold temperature can be confirmed with an infrared thermometer.

9.1.1 The compaction temperature range is defined as the range of temperatures where the unaged asphalt binder has a viscosity of 280 ± 30 mPa·s measured in accordance with Test Method D4402/D4402M. See also Note 8.

9.2 Verify the settings on the compactor. Unless noted otherwise, the SGC shall be initialized to provide specimen compaction using the settings described in 5.1. The number of gyrations for specimens used for volumetric properties shall be determined by AASHTO R 35 or other governing specification. The final compacted specimen height may be used as the stop criteria for mechanical test specimens compacted to a target air void.

9.3 At the end of the conditioning period, remove the loose mix sample and the compaction mold assembly from the oven. Place a paper disk inside the mold to aid separation of the specimen from the base plate after compaction.

NOTE 12—Some SGC models permit the mix to be placed into the mold after the mold is loaded into the machine.

9.4 At the end of the compaction process, remove the mold assembly from the SGC. After a suitable cooling period, extrude the compacted specimen from the mold and remove the paper disk.

NOTE 13—Some compactor configurations may permit extruding from the mold prior to removing the mold from the compactor.

NOTE 14—The purpose of the cooling period is to ensure that the specimen will not deform when it is extruded. Cooling may be facilitated using a fan. For some specimens with high air voids (7 % or more) that will be used in physical property testing, this period may be as long as 15 min or more. Operator experience should dictate the length (and necessity) of the cooling period to avoid deformation of the compacted mixture specimen. Under no circumstances should specimens which have bulged or otherwise deformed be used for any testing purposes.

9.5 Place the extruded specimen on a flat surface in an area where it can cool undisturbed to room temperature. Clean the mold and end plates then place the compaction mold and end plates back in the oven for a minimum of 20 min before reusing. See also Note 11.

9.6 Collect the printout or save the data to file of the height measurements for each gyration.

10. Densification Procedure

10.1 When the specimen densification is to be monitored, as in a volumetric mix design, the following steps are required in addition to those specified in Section 9.

10.1.1 Determine the mass of the extruded specimen to the nearest 0.1 g. Determine the bulk specific gravity of the extruded specimen in accordance with Test Method D1188/D1188M, D2726/D2726M, or D6752/D6752M.

10.1.2 Determine the maximum theoretical specific gravity of the loose mixture in accordance with Test Method D2041/D2041M or D6857/D6857M, using a companion sample. The companion sample shall be conditioned to the same extent as the compacted specimen using AASHTO R 30.

11. Relative Density Calculations

11.1 At the completion of Section 10 determinations, determine the relative density at any given gyration of interest as follows:

$$G_{mbx} = G_{mbfinal}\left(\frac{h_{final}}{h_x}\right) \tag{1}$$

$$\%G_{mm} = \left(\frac{G_{mbx}}{G_{mm}}\right)100 \tag{2}$$

where:

G_{mbx} = bulk specific gravity of the extruded specimen at any gyration, x,
G_{mm} = maximum theoretical specific gravity of the mixture (companion sample),
h_{final} = height of the specimen recorded at the final gyration, mm,
h_x = height of the specimen recorded at any gyration, x, during the compaction process, mm,
$G_{mbfinal}$ = bulk specific gravity of the extruded specimen at the final gyration, and
$\%G_{mm}$ = relative density at any gyration, x.

NOTE 15—The relative density calculated at any gyration (*x*) using the above equation is an approximation based on back calculation. Due to inherent variability in aggregates as well as blending and mixing of HMA specimens, the actual relative density of an alternate specimen produced using the same materials at any given number of gyrations (*x*) may not exactly correlate with the relative density calculated using the above equation.

NOTE 16—AASHTO R 99 provides guidance on troubleshooting density discrepancies between laboratories.

12. Report

12.1 Report the following information:

12.1.1 Project details;