



Designation: **D7115 – 10 (Reapproved 2015) D7115 – 20**

## Standard Test Method for Measurement of Superpave Gyrotory Compactor (SGC) Internal Angle of Gyration Using Simulated Loading<sup>1</sup>

This standard is issued under the fixed designation D7115; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method covers the procedure for the measurement of the Superpave Gyrotory Compactor (SGC) internal angle of gyration using an instrument capable of simulating loading conditions similar to those created by a ~~hot mix asphalt~~ asphalt mixture specimen.

1.2 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard. The value given in rotations per minute is provided for information regarding commonly used units.

1.2.1 ~~IEEE/ASTM SI 10~~, American National Standard for ~~the Use of International System of Units (SI): The Modern Metric System~~, Metric Practice, offers guidance where use of decimal degrees for plane angles (versus radians) and revolutions per minute for rate of gyration (versus radians per second) is acceptable within the ~~IEEE/ASTM SI 10~~ system when used on a minimal basis.

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~~ safety, health, and health ~~environmental~~ 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:*<sup>2</sup>

[C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials](#)

[D8 Terminology Relating to Materials for Roads and Pavements](#)

[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](#)

[D6752/D6752M Test Method for Bulk Specific Gravity and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method](#)

[D6925 Test Method for Preparation and Determination of the Relative Density of Asphalt Mix Specimens by Means of the Superpave Gyrotory Compactor](#)

[E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)

~~IEEE/ASTM SI 10~~ American National Standard for ~~the Use of International System of Units (SI): The Modern Metric System~~ Metric Practice

### 3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology [D8](#).

3.2 ~~Definitions:~~ Definitions of Terms Specific to This Standard:

<sup>1</sup> 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.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.1 bottom internal angle,  $n$ —the angle formed between the internal mold diameter and the lower mold end plate as a mold is gyrated in an SGC.

3.2.2 eccentricity,  $e, n$ —the distance away from the axis of gyration at which a force ( $F$ ) is acting at one end of an SGC mold.

3.2.2.1 Discussion—

This use of the term eccentricity is consistent with previous published reports describing the mechanics of gyratory compaction.<sup>3</sup>

3.2.3 effective internal angle,  $n$ —the average of the top internal angle and the bottom internal angle.

3.2.4 external angle—angle,  $n$ —the angle formed between the external mold diameter and a stationary reference axis of the machine frame as a mold is gyrated in the SGC.

3.2.5 internal angle—angle,  $n$ —the angle formed between the internal mold diameter and a mold end plate as a mold is gyrated in an SGC.

3.2.6 top internal angle—standard SGC volumetric specimen,  $n$ —the angle formed between the internal mold diameter and the upper mold end plate as a mold is gyrated in an SGC: a standard sized asphalt mixture specimen prepared using an SGC for purposes of volumetric mix design.

3.2.6.1 Discussion—

Such a standard specimen, prepared in accordance with Test Method **D6925**, has a diameter of 150 mm and a final compacted height of  $115 \pm 5$  mm.

3.1.4 bottom internal angle—the angle formed between the internal mold diameter and the lower mold end plate as a mold is gyrated in an SGC.

3.1.5 effective internal angle—the average of the top internal angle and the bottom internal angle.

3.2.7 tilting moment—moment,  $n$ —a force ( $F$ ) acting at one end of an SGC mold platen in a direction parallel to the axis of gyration, but acting at some distance ( $e$ ) away from that axis. The tilting moment at one end of the mold platen is computed as the product of this distance ( $e$ ) and force ( $F$ ).

3.2.8 top internal angle,  $n$ —the angle formed between the internal mold diameter and the upper mold end plate as a mold is gyrated in an SGC.

3.2.9 total moment—moment,  $M, n$ —the sum total ( $M$ ) of the tilting moment acting at the top of the mold and the tilting moment acting at the bottom of the mold.

3.1.8 eccentricity—the distance ( $e$ ) away from the axis of gyration at which a force ( $F$ ) is acting at one end of an SGC mold. This use of the term eccentricity is consistent with previous published reports describing the mechanics of gyratory compaction.<sup>3</sup>

3.1.9 standard SGC volumetric specimen—a standard sized hot mix asphalt specimen prepared using an SGC for purposes of volumetric mix design. Such a standard specimen, prepared in accordance with Test Method **D6925**, has a diameter of 150 mm and a final compacted height of  $115 \pm 5$  mm.

#### 4. Summary of Test Method

4.1 The internal angle of gyration of an SGC is measured dynamically with an instrument inserted into the SGC mold.

4.2 A load (moment) is induced on the SGC while the internal angle is simultaneously measured. The simulated loading conditions are similar to those created by compaction of a standard SGC volumetric specimen.

4.3 The internal angles at each end of the mold are measured and then averaged to obtain the effective internal angle of gyration.

#### 5. Significance and Use

5.1 SGCs are used to produce hot mix asphalt (HMA) mixture specimens in the laboratory to assess volumetric properties and predict pavement performance. In the fabrication of an SGC specimen in accordance with Test Method **D6925**, loose HMA asphalt mixture is placed inside a metal mold, which is then placed into an SGC. A constant consolidation pressure is applied to the sample while the mold gyrates at a nominally constant angle (referred to as the internal angle of gyration) and rate. Consistency in the density of the asphalt specimens produced as measured by Test Methods Method **D2726/D2726M** or **D6752/D6752M** is very important to the validity of the tests performed. Specimens of a consistent density are produced when an SGC maintains a constant pressure and a known constant internal angle of gyration during the compaction process.

<sup>3</sup> Guler, M., Bahia, H. U., Bosscher, P. J., and Plesha, M. E., “Device for Measuring Shear Resistance of Hot Mix Asphalt in Gyratory Compactor,” *Transportation Research Record* for Measuring, Vol 1723, Shear Resistance, No. 1 of Hot Mix Asphalt in Gyratory Compactor,” *Transportation Research Record* 1723, TRB, National Academy of Sciences, Washington, DC, 2000, pp. 116–124.

5.2 There are several manufacturers and models of SGC. Each model employs a unique method of setting, inducing, and maintaining the internal angle of gyration. Each model also employs a unique calibration system to measure the external angle of gyration. These existing calibration systems ~~can not~~ cannot be used universally on all of the different SGC models commercially available. Inconsistencies in asphalt specimens produced on different SGC models have been at least partially attributed to variations in the angle of gyration.

5.3 This method describes instruments and processes that can be used to independently measure the internal angle of gyration of any ~~manufacturers'~~ manufacturer's SGC model under simulated loading conditions. The external shape of the instrument chassis ~~assures~~ ensures that the points of physical contact between the mold end plates and the instrument occur at a fixed and known distance away from the axis of gyration. As a result, the vertical load is applied at these fixed points, creating tilting moments at each end of the mold.

5.4 Unless otherwise specified, a tilting moment of ~~466.5 N-m~~ 466.5 N-m shall be applied to the SGC by the instrument while making this measurement.

NOTE 1—The quality of the results produced by this test method 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 Practice Specification D3666 are generally considered capable of competent and objective ~~testing/sampling/inspection/etc.~~ testing, sampling, inspection, etc. Users of this test method 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.

NOTE 2—A 466.5 N-m tilting moment corresponds to a 22 mm eccentric on the AFLS1 or a ~~21 deg~~ 21° cone angle on the DAVII-HMS with an applied load of 10603 N (600 kPa at a 150 mm diameter specimen setting).

## 6. Interferences

6.1 Debris on the SGC mold, base plates, ram head, reaction surfaces, or instrument can cause errant measurement results. Extreme care should be taken to thoroughly clean the SGC, mold, instrument, and any work areas that will be utilized during the measurement procedure.

6.2 Scarring or irregular surfaces on mold walls and end plates is also known to cause incorrect results. Do not use any equipment that shows signs of damage. The precision required in the execution of this test method necessitates that extreme care must be taken to avoid errors from damaged or improperly maintained equipment.

6.3 Worn parts on the instrument can lead to erroneous measurements.

## 7. Apparatus

7.1 An instrument capable of being gyrated inside an SGC mold which induces tilting moments at each end of the SGC mold while simultaneously measuring an internal angle of gyration.

7.1.1 *Data Acquisition*—The timing of the data acquisition system may be automatically triggered by the start of the gyration process. Provision for excluding a known number of initial gyrations from the angle measurement may be provided (initial delay period), and the angle shall be measured throughout a known number of subsequent gyrations (data acquisition period). The durations of the initial delay and the data acquisition periods may be programmable or fixed.

7.1.2 *Display Options*—The angle measurement result(s) may be viewable on a display built into the instrument chassis or retrievable from the instrument by means of a communications port, or both.

7.1.3 *Temperature Measurement*—The instrument may optionally have a means for displaying, recording, or otherwise indicating its internal temperature during the angle measurement process.

7.1.4 *Static Angle Gage*—A National Institute of Standards and Technology (~~NIST~~)-traceable (~~NIST~~) traceable angle gage device with one or more known angles used to calibrate and to verify the calibration of the angle measurement instrument.

7.1.5 *Wear Protection Plates*—Thin steel plates (optional) which protect the SGC mold end plates from any cosmetic damage ~~by the contact rings.~~

7.2 *Superpave Gyratory Compactor (SGC)* and associated equipment as described in Test Method D6925. The SGC shall be in good repair with the compaction pressure, specimen height measurement system, and gyration rate verified to be within specifications. The mechanisms used to induce and maintain the angle of gyration shall be set and maintained within the manufacturer's guidelines.

7.2.1 The SGC molds, mold end plates, base platens, and ram head surface smoothness shall be confirmed to be within the specifications of Test Method D6925. Any equipment not meeting these requirements shall not be used.

## 8. Preparation of Apparatus

8.1 Before each use of the angle measurement instrument, verify the angle measurement system using the static angle gage according to manufacturer's instructions. The static angle gage, which can apply one or more known angles to the instrument, is used to confirm that the instrument is operating within calibration. The instrument and the static angle gage must be at the ~~same,~~ same uniform, stable temperature for the verification to be accurate.

NOTE 3—These instruments typically have an operating temperature range of 20 to ~~40°C~~ 40°C. Consult the manufacturer's instructions for specific

temperature limitations during calibration, verification, and use within the SGC.

8.2 Be sure the probe tips and contact rings on the angle measurement instrument are free of debris.

8.3 Prepare a clean compaction mold assembly.

**NOTE 4**—Accumulation of ~~HMA asphalt mix or binder~~ on mold surfaces, mold end plates, base platens, or ram head surfaces, or ~~combination combinations~~ thereof, directly impacts the instrument's ability to accurately measure the internal angle of gyration. Use mineral spirits or another appropriate solvent to clean these surfaces.

~~8.4 Perform the~~ The internal angle measurement can be taken with the SGC mold at room temperature. Optionally, the measurement may be made with the mold temperature or at an elevated temperature. If the angle measurement is to be made at an elevated temperature, then place the SGC mold in an oven at the desired temperature  $\pm 5^{\circ}\text{C}$   $5^{\circ}\text{C}$  for a minimum of 45 min prior to making the first angle measurement. Do not place the angle measurement instrument in the oven. Mold temperatures other than room temperature used during angle measurement shall be noted on the report.

**NOTE 5**—The SGC manufacturer may recommend measurement of the angle at an elevated temperature for those SGC models where the angle changes with mold temperature.

**NOTE 6**—These instruments typically have an operating temperature range of 20 to ~~40°C~~  $40^{\circ}\text{C}$ . After use in a hot mold, the angle measurement instrument can be cooled by using a fan to blow ambient air over the instrument or by placing it in front of an air conditioner. Elevating the instrument above the table surface so as to permit maximum airflow over the entire instrument will increase the rate of cooling. Do not cool the instrument below room temperature. Consult the manufacturer's instructions for specific temperature limitations during calibration, verification, and use within the SGC.

8.5 Verify the settings on the compactor. Unless noted otherwise, the SGC shall be initialized to provide specimen compaction using a consolidation pressure of  $600 \pm 18$  kPa, and the gyration rate shall be ~~30 ± 0.5 rpm~~  $0.5 \pm 0.0083$  Hz ( $30 \pm 0.5$  rpm).

8.6 Set the number of gyrations on the SGC in accordance with the recommendations of the manufacturer of the angle measurement instrument. ~~Typically, ten gyrations are sufficient to obtain an accurate angle measurement using simulated loading.~~

**NOTE 7**—Typically, ten gyrations are sufficient to obtain an accurate angle measurement using simulated loading.

## 9. Calibration and Standardization

9.1 The angle measurement instrument requires periodic ~~standardization~~ calibration/standardization/verification. The system shall be ~~standardized~~ verified prior to initial use and at least once every ~~12~~ twelve months thereafter. This annual standardization shall follow instrument manufacturer recommendations and include the following:

9.1.1 ~~Standardization~~ Calibration of the static angle gage with a ~~NIST traceable~~ NIST-traceable measurement system, and

9.1.2 Standardization of the angle measurement instrument.

## 10. Procedure

10.1 The average internal angle is based on six individual angle measurements as follows:

10.1.1 The top internal angle is measured in triplicate.

10.1.2 The bottom internal angle is measured in triplicate.

10.2 Each of the six individual angle measurements is performed as follows:

10.2.1 Arm the angle measurement instrument for collecting data.

10.2.2 Place the angle measurement instrument inside the SGC mold. Orient the instrument probes or reference base as appropriate to measure the top or bottom angle.

**NOTE 8**—The operator may wish to use a specimen extruder to elevate the bottom mold plate to a position where insertion of the angle measurement instrument into the SGC mold is easier.

10.2.3 Place the SGC mold inside the SGC.

**NOTE 9**—For some SGCs, it may be more convenient to first place the mold in the SGC, and then place the angle measurement instrument in the mold.

10.2.4 Initiate the compaction process. ~~For most SGCs, this is an automatic process consisting of pressing a button to start the compaction process. The SGC automatically applies the ram pressure, induces the angle, and gyrates the mold to the specified number of gyrations.~~

**NOTE 10**—For most SGCs, this is an automatic process consisting of pressing a button to start the compaction process. The SGC automatically applies the ram pressure, induces the angle, and gyrates the mold to the specified number of gyrations.

10.2.5 Remove the angle measurement instrument from the SGC mold.

**NOTE 11**—Use caution when removing the instrument, especially when using a power extruder. Take care that the instrument does not get caught or damaged during the extrusion process.

10.2.6 Record the angle result reported by the instrument to nearest  $0.01^{\circ}$ . Record which angle (top or bottom) and which triplicate (1 or 2 or 3) was measured.

## 11. Calculations

11.1 Calculate the average top internal angle as follows: