Test Procedure for

COMPACTING BITUMINOUS SPECIMENS USING THE SUPERPAVE GYRATORY COMPACTOR (SGC)

TxDOT Designation: Tex-241-F

Effective Date: July 2021

1. SCOPE

1.1 Use this test method to:

- compact cylindrical specimens of hot-mix asphalt (HMA) using the Superpave gyratory compactor;
- prepare specimens for determining the mechanical and volumetric properties of HMA; and

  Note 1—The specimens simulate density, aggregate orientation, and structural characteristics obtained in the actual roadway when proper construction procedure is used in the placement of the paving mix.
- monitor the density of test specimens during their preparation and for field control of an HMA production process.

1.2 Refer to Table 1 for Superpave and conventional mix nomenclature equivalents. Replace conventional nomenclature with Superpave nomenclature when required.

Table 1
Nomenclatures and Definitions

Nomenclatures		Definitions
Conventional	**Superpave**	
G_a	G_{mb}	Bulk specific gravity of the compacted mixture
G_r	G_{mm}	Theoretical maximum specific gravity

1.3 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. APPARATUS

2.1 *Superpave gyratory compactor (SGC).*

2.1.1 The compactor is an electrohydraulic or electromechanical compactor with ram and ram heads that are restrained from revolving during compaction.

2.1.2 The axis of the ram is perpendicular to the platen of the compactor.

2.1.3 The compactor tilts the specimen molds at an internal angle of 1.16 ± 0.02° (20.2 ± 0.35 mrad) and gyrates specimen molds at a rate or 30.0 ± 0.5 gyrations per minute throughout compaction.

2.1.4 The compactor is designed to permit the specimen mold to revolve freely on its tilted axis during gyration.

2.1.5 The ram applies and maintains a pressure of 600 ± 18 kPa (87 ± 2 psi) perpendicular to the cylindrical axis of the specimen during compaction.

Note 2—This stress calculates to 10,600 ± 310 N (2,383 ± 70 lbf) total force for 150 mm (5.912 in.) specimens.

2.2 *Specimen height measurement and recording device.*

2.2.1 When monitoring specimen density during compaction, provide a means to continuously measure and record the height of the specimen to the nearest 0.1 mm during compaction, once per gyration.

Note 3—Specimen height monitoring is for informational purposes only during design.

2.2.2 The system should be capable of downloading or printing test information, such as specimen height per gyration. In addition to a printer, the system may include a computer and suitable software for data acquisition and reporting.

2.3 *Specimen molds.*

2.3.1 Specimen molds must have steel walls that are at least 7.5 mm (0.3 in.) thick and have a minimum Rockwell hardness HR-C 48.

2.3.2 Molds must have an inside diameter of 149.90–150.00 mm (5.901–5.912 in.) and be at least 250 mm (10 in.) high.

2.3.3 The inside finish of the molds must have a root mean square (rms) of 1.60 µm or smoother.

Note 4—Measure smoothness according to ANSI B46.1. One source of supply for a surface compactor, which is used to verify the rms value of 1.60 µm, is GAR Electroforming, Danbury, Connecticut.

2.4 *Ram heads and mold bottoms.*

2.4.1 Ram heads and mold bottoms must be fabricated from steel with a minimum Rockwell hardness of C48.

2.4.2 The ram heads must be perpendicular to its axis.

2.4.3 The platen side of each mold bottom must be flat and parallel to its face.

2.4.4 All ram and base plate faces (the sides presented to the specimen) must be ground flat to meet smoothness the requirements of ANSI B 46.1 and must have a diameter of 149.50–149.75 mm (5.885–5.896 in.)

2.5 *Mercury thermometer,* marked in 5°F (3°C) divisions or less, or a digital thermometer capable of measuring the temperature specified in this test procedure.

2.6 *Balance,* Class G2 in accordance with Tex-901-K, with a minimum capacity of 10,000 g.

2.7 *Oven,* capable of maintaining a temperature of at least 325 ± 5°F (163 ± 3°C).

2.8 *Pans,* metal, with flat bottom.

2.9 *Metal material handling chute.*

2.10 *Scoop, spatula, trowel.*

2.11 *Paper disks.*

2.12 *Insulating gloves.*

2.13 *Lubricating materials per manufacturers recommendations.*

3. SAFETY PRECAUTIONS

3.1 Use standard safety precautions and protective clothing when handling hot asphalt mixtures, molds, and equipment.

4. CALIBRATION

4.1 Items requiring periodic verification of calibration include:

- ram pressure,
- angle of gyration,
- gyration frequency,
- LVDT (or other means used to continuously record the specimen height), and
- oven temperature.

4.2 Verification of the mold and platen dimensions and the inside finish of the mold are also required.

4.3 When the computer and software options are used, periodically verify the data processing system output using a procedure designed for such purposes.

4.4 The manufacturer, other agencies providing such services, or in-house personnel may perform the verification of the calibration system standardization and quality checks. Frequency of verification must follow manufacturer's recommendations.

5. PREPARATION OF THE SGC

5.1 Turn on the compactor and allow it to warm up before the asphalt concrete mixture is ready for placement in the mold.

5.2 Verify settings for angle and pressure.

5.3 Select gyration or height mode. Enter the design number of gyrations or required specimen height according to the specification or test procedure.

Note 5—Gyration mode is normally used when molding samples for volumetric properties. Height mode is normally used when molding samples for performance testing such as Hamburg, Overlay, Cantabro, and IDT.

5.4 Lubricate bearing surfaces as needed.

5.5 Lubricate the surface of the rotating base and the surface of the four rollers.

5.6 Follow the instructions in Sections 5.6.1 through 5.6.2 when monitoring the specimen height.

5.6.1 Before placing the material in the mold, turn on the device for measuring and recording the height of the specimen. Verify that the readout is in the proper units (mm) and that the recording device is ready.

5.6.2 If using a computer, prepare it to record the height data and enter the header information for the specimen.

6. MIXTURE PREPARATION

6.1 For laboratory-produced mixtures, proceed to Section 6.2. For plant-produced mixtures, proceed to Section 6.3. For mixtures requiring re-heating, proceed to Section 6.4.

Note 6—Mixtures requiring re-heating are defined as laboratory or plant-produced mixtures that will be cooled to ambient temperature and transported to another laboratory for testing.

6.2 *Laboratory-Produced Mixtures:*

6.2.1 Combine aggregates and prepare the laboratory mixture as described in Tex-205-F.

6.2.2 Split the mixture into the appropriate sample size.

Note 7—The sample weight of test specimens will vary based on the selected compaction method and the test to be performed. If a target density is desired for performance testing, adjust the sample weight to create a given density for a specified height. If the specimens are to be used for determining volumetric properties, adjust the sample weight to yield results based on gyration control.

6.2.3 Proceed to Section 6.5.

6.3 *Plant-Produced Mixtures:*

6.3.1 Sample the plant-produced mixture in accordance with Tex-222-F.

6.3.2 Split the mixture into the appropriate sample size. Refer to Note 7.

6.3.3 Proceed to Section 6.5.

6.4 *Plant-Produced or Lab-Produced Mixtures Requiring Re-Heating:*

6.4.1 For plant-produced mixtures, sample the mixture in accordance with Tex-222-F. For laboratory produced mixtures, combine aggregates and prepare the laboratory mixture as described in Tex-205-F.

6.4.2 If transferring the material to a different lab for testing, place the material in a paper bag or cardboard box for shipping and labeling. The sample thickness in the container must not exceed 3 in.

Note 8—Do not use canvas sacks as shipping containers.

Note 9—Do not send in pre-molded specimens when submitting material for performance tests such as IDT, IDEAL-CT, Hamburg, Cantabro, and Overlay.

6.4.3 Proceed to Section 6.5.

6.5 Select the compaction temperature from Table 2 based on the asphalt binder specified on the plans. Only use the target discharge temperature as the compaction temperature when it is less than the temperature shown in Table 2. Set the oven temperature to the temperature selected from Table 1.

Note 10—If using reclaimed asphalt pavement (RAP) or recycled asphalt shingles (RAS) and a substitute PG binder instead of the PG binder originally specified, defer to the originally specified binder grade when selecting the compaction temperature.

6.6 Place the compaction mold, base, and the top plate in an oven at the selected compaction temperature for a minimum of 60 min. before compaction.

6.7 Place the material into an oven at the selected compaction temperature. For laboratory or plant-produced mixtures samples that do not require reheating, proceed to Section 6.7.1. For shipped laboratory or plant-produced mixture that requires reheating, proceed to Section 6.7.2.

6.7.1 Remove the sampled material from the sampling container and place it into a large pan. Thoroughly mix the sample and split into the appropriate sample size and place into a metal pan. Refer to Note 7. Spread the material in the metal pan at a uniform thickness of 2.25 in. ± 0.5 in. and place the split samples back into the oven. Cure the mix in the oven for 2 hr. ± 5 min. Monitor the internal temperature of the mix by inserting a calibrated thermometer or temperature probe into the loose material and leaving in the oven. If the internal temperature of the mixture has not reached the specified compaction temperature after the 2-hr. cure, continue to monitor the sample every 15 min. until the compaction temperature has been reached. Once the sample mixture has reached the specified compaction temperature and the curing period is complete, proceed to Section 8 to mold the specimen.

6.7.2 Place the sealed sample container into the oven at the selected compaction temperature until the material can be easily broken apart. Remove the sampled material from the container and place it into a large pan. Thoroughly mix the sample and split into the appropriate sample size and place into a metal pan. Refer to Note 7. Spread the material in the metal pan at a uniform thickness of 2.25 in. ± 0.5 in. and place the split samples back into the oven. Cure the mix in the oven for 1.5 hr. ± 5 min. at the selected curing temperature. Monitor the internal temperature of the mix by inserting a calibrated thermometer or temperature probe into the loose material and leaving in the oven. If the internal temperature of the mixture has not reached the specified compaction temperature after the 1.5 hr. cure, continue to monitor the sample every 15 min. until the compaction temperature has been reached. Once the sample mixture has reached the specified compaction temperature and the curing period is complete, proceed to Section 8 to mold the specimen.

Note 11—When molding samples for performance testing, trial samples are often required to determine proper mold weights. To ensure proper sample aging, do not leave loose material in the oven while the trial is being performed.

Note 12—When molding samples to a target height of 62 mm, a circular pan with the following dimensions will meet the required curing thickness: top diameter of 10.25 in. and a bottom diameter of 8.5 in.

Note 13—When molding samples to a target height of 115 mm, a circular pan with the following dimensions will meet the required curing thickness: top diameter of 12.5 in. and a bottom diameter of 9.75 in.

7. COMPACTION TEMPERATURES

7.1 Use the compaction temperatures in Table 2 when molding samples. Use the same temperature for both curing and compaction of these mixtures.

7.2 Compaction temperatures not listed in Table 2 may be used when shown on the plans or approved by the Engineer. For guidance on materials not listed in Table 2 or materials containing modifying additives, RAP, or RAS, consult the Flexible Pavements Section of the Materials and Tests Division.

Table 2
Curing and Compaction Temperatures

Binder[1]	**Temperature, °F**[2]
PG 58 - 28	250
PG 64 - 22	250
PG 64 - 28	275
PG 70 - 22	275
PG 70 - 28	300
PG 76 - 22	300
PG 76 - 28	300
Asphalt Rubber (A-R)	300

Note: Mixtures must be compacted at the selected compaction temperature within a tolerance of ± 5°F (± 3°C).

1. If using RAP or RAS and a substitute PG binder instead of the PG binder originally specified on the plans, defer to the originally specified binder grade when selecting the compaction temperature.
2. Only use the target discharge temperature when it is less than the compaction temperature shown.

8. PROCEDURES

8.1 *Compaction:*

8.1.1 Use the design number of gyrations (N_{des}) or height for compaction according to the specification or as shown on the plans.

Note 14—When the mixture appears dry and lacking asphalt, lower the N_{des} value to increase the optimum asphalt content of the mixture.

8.1.2 Following oven curing, remove the heated mold and base plate from the oven and place a paper disk on the bottom of the mold.

8.1.3 To minimize segregation, place the mixture into the metal material handling chute by quickly inverting the pan upside down. Use the metal material handling chute to then place material into the mold in one lift. Take care to avoid segregation in the mold.

8.1.4 After all the mix is in the mold, level the mix with a spatula and place another paper disk and the top plate on the leveled material.

8.1.5 Load the specimen mold into the compactor and center the mold under the loading ram.

8.1.6 Press the start button to lower the ram. The pressure on the specimen should reach 600 ± 18 kPa (87 ± 2 psi).

8.1.7 The compactor should then apply a 1.16 ± 0.02° (20.2 ± 0.35 mrad) internal angle to the mold assembly and begin the gyratory compaction.

8.1.8 Allow compaction to proceed until completion of the specified number of gyrations or height and until the gyratory mechanism shuts off.

8.1.8.1 When monitoring the specimen height, record the specimen height to the nearest 0.1 mm (0.004 in.) after each revolution.

8.1.9 Once the machine removes the angle from the mold assembly and raises the loading ram, remove the mold from the compactor, and extrude the specimen from the mold.

Note 15—Do not immediately extrude the specimen from the mold for lean, rich, and tender mixtures, for mixtures containing asphalt rubber binder, or for mixtures compacted to a density less than 82% to prevent deformation of the specimen. Allow the mold to cool for approximately 10 min. or more in front of a fan.

8.1.10 Carefully remove the paper disks from the top and bottom of the specimens.

Note 16—When molding multiple specimens, place the mold in the oven for at least 5 min. before reusing. The use of multiple molds will expedite the compaction process.

8.2 *Density:*

8.2.1 Use the maximum specific gravity (G_r) of the loose mix determined in accordance with Tex-227-F using a companion sample. For permeable friction course (PFC) mixtures, use a back-calculated G_r in accordance with Tex-207-F.

Note 17—Oven-cure the companion sample at the same temperature and for the same length of time as the compaction sample.

8.2.2 Record the mass of the extruded specimen to the nearest tenth gram and determine the bulk specific gravity (G_a) of the extruded specimen in accordance with Tex-207-F.

8.2.3 Calculate the relative density of the extruded specimen ($\%G_{mm}$) in accordance with Section 9.1.

Note 18—Estimations of the relative density of the specimen can be made at any point in the compaction process based on the specimen height accordance with Section 9.2.

9. CALCULATIONS

9.1 Calculate $\%G_{mm}$:

$$\%G_{mm} = \frac{G_a}{G_r} * 100$$

Where:

$\%G_{mm}$ = relative density of the extruded specimen expressed as a percent of the theoretical maximum specific gravity

G_a = bulk specific gravity of the extruded specimen

G_r = theoretical maximum specific gravity of the mix

9.1.1 Report results to the nearest 0.001.

9.2 Estimate the percent compaction ($\%G_{mmx}$) at any point in the compaction process:

$$\%G_{mmx} = \frac{G_a h_m}{G_r h_x} \times 100$$

Where:

$\%G_{mmx}$ = relative density expressed as a percentage of the theoretical maximum specific gravity

G_a = bulk specific gravity of the extruded specimen

G_r = theoretical maximum specific gravity of the mix

h_m = height of the extruded specimen, mm

h_x = height of the specimen after "x" gyrations, mm

9.2.1 Report results to the nearest 0.001.

10. ARCHIVED VERSIONS

10.1 Archived versions are available.