Test Procedure for

DETERMINING DENSITY OF COMPACTED BITUMINOUS MIXTURES

TxDOT Designation: Tex-207-F

Effective Date: January 2020

1. SCOPE

1.1 This test method determines the bulk specific gravity (G_a) of compacted bituminous mixture specimens. Use the G_a of the specimens to calculate the degree of densification or percent compaction of the bituminous mixture.

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

Table 1
Nomenclatures and Definitions

Nomenclatures		Definitions
Conventional	**Superpave**	
AC	-	Asphalt Content
A_g	P_s	Percent by weight of aggregate in the mixture
A_s	P_b	Percent by weight of asphalt binder in the mixture
G_a	G_{mb}	Bulk specific gravity of compacted specimens
G_e	G_{se}	Effective specific gravity of the combined aggregates
G_r	G_{mm}	Theoretical maximum specific gravity
G_{rc}	G_{mm}	Theoretical maximum specific gravity corrected for water absorption during test
G_s	G_b	Specific gravity of the asphalt binder determined at 77°F (25°C)
G_t	$G_{max\text{-}theo}$	Calculated theoretical maximum specific gravity of the mixture at the specified AC

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. DEFINITIONS

2.1 *Bulk Specific Gravity (G_a)*—the ratio of the weight of the compacted bituminous mixture specimen to the bulk volume of the specimen.

2.2 *Percent Density or Percent Compaction*—the ratio of the actual G_a of the compacted bituminous mixture specimen to the theoretical maximum specific gravity of the combined aggregate and asphalt contained in the specimen expressed as a percentage.

PART I—BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES

3. SCOPE

3.1 Use this procedure for all compacted bituminous mixtures, except use Part VI for mixtures with more than 2.0% water absorption.

4. APPARATUS

4.1 *Balance*, Class G2 in accordance with Tex-901-K, minimum capacity of 10,000 g, equipped with suitable apparatus to permit weighing the specimen while suspended in water.

4.2 *Suspension Apparatus, Non-Absorptive String, Metal Bucket, or a Cage*, attached to the balance with a metal wire or a non-absorptive string.

4.3 *Mercury Thermometer,* marked in 2°F (1°C) divisions or less, or digital thermometer, capable of measuring the temperature specified in the test procedure.

4.4 *Water Bath with a Tank Heater and Circulator,* for immersing the specimen in water while suspended, equipped with an overflow outlet for maintaining a constant water level.

4.5 *Towel,* suitable for surface drying the specimen.

4.6 *Vacuum Device,* such as Coredryer (optional).

4.7 *Measuring Device,* such as a ruler, calipers, or measuring tape.

4.8 *Drying Oven,* capable of attaining the temperature specified in the test procedure.

5. TEST SPECIMENS

5.1 Test specimens may be laboratory-molded mixtures or pavement cores.

5.2 Avoid distorting, bending, or cracking the specimens during and after removal from pavements or molds. Store the specimens in a cool place.

5.3 Obtain cores in accordance with Tex-251-F, Part I.

5.4 *Laboratory-Molded Specimens:*

5.4.1 Measure and record the specimen height to the nearest 1/16 in.

5.5 *Pavement Cores*

5.5.1 Prepare pavement cores for testing in accordance with Tex-251-F, Part II.

6. PROCEDURES

6.1 For specimens containing moisture, follow the instructions in Sections 6.2–6.9. For laboratory-molded specimens, perform the instructions in Sections 6.3–6.9.

6.2 Place the specimen in an oven with the flat side of the specimen on a flat surface to complete the drying process. Oven-dry the specimen for a minimum of two hr. at a temperature of 115 ± 5°F (46 ± 3°C) to constant weight. "Constant weight" is the weight at which further oven drying does not alter the weight by more than 0.05% in a two hr. or longer drying interval when calculated in accordance with Section 7.1.

Note 1—The oven drying temperature can be reduced to a temperature no lower than 100°F (38°C) provided that the specimen remains in the oven for a minimum of eight hr.

Note 2—As an option, for specimens not subject to further testing and evaluation, rapid dry in an oven at a temperature of 140°F (60°C), for a maximum of 12 hr. to constant weight.

Note 3—As an option, use a Coredryer in conjunction with or instead of a drying oven. Dry all samples to a constant weight as defined in Section 6.2.

6.3 Allow the specimen to cool, and then weigh in air to the nearest 0.1 g.

6.4 Record and designate this weight as *A* in Section 7.2.

6.5 Unplug or turn off the water circulator in the water bath while obtaining the submerged sample weight. Attach the suspension apparatus to the scale and submerge in water. Tare the scale with the suspension apparatus submerged in water.

6.6 Immerse the specimen in a water bath at 77 ± 3°F (25 ± 2°C).

6.7 Leave the sample in the water for three min. ± 15 sec. When the scale readings stabilize, record the specimen weight and designate as *C* in Section 7.2.

6.8 Remove the specimen from water. Dry the surface of the specimen by blotting gently with a damp towel for no longer than 20 sec. To facilitate drying, gently rotate the specimen while blotting, if necessary; however do not shake, sling, or perform any action that removes water from within the specimen.

6.9 Weigh the specimen in air. Record as the saturated surface dry weight (SSD) and designate as *B* in Section 7.2.

7. CALCULATIONS

7.1 Calculate the percent difference in weight:

$$PercentDifference = \left(\frac{InitialWeight - FinalWeight}{InitialWeight} \right) * 100$$

7.2 Calculate G_a and percent of water absorbed by the specimen:

$$G_a = \frac{A}{B - C}$$

Where:

G_a = bulk specific gravity,

A = weight of dry specimen in air, g,

B = weight of the SSD specimen in air, g, and

C = weight of the specimen in water, g.

$$Percent\ absorption = \frac{B - A}{B - C} \times 100$$

Where:

A = weight of dry specimen in air, g,

B = weight of the SSD specimen in air, g, and

C = weight of the specimen in water, g.

Note 4—If the percent absorption exceeds 2.0%, use Part VI.

PART II—BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES USING PARAFFIN

8. SCOPE

8.1 The paraffin method is no longer an accepted process.

8.2 Refer to Part VI of this test procedure for absorptive mixtures (those with more than 2.0% water absorption).

PART III—DETERMINING IN-PLACE DENSITY OF COMPACTED BITUMINOUS MIXTURES (NUCLEAR METHOD)

9. SCOPE

9.1 Use this procedure to determine the in-place density of compacted bituminous mixtures using a nuclear density gauge.

10. APPARATUS

10.1 *Nuclear Density Gauge.*

10.2 *Portable Reference Standard.*

10.3 *Calibration Curves for the Nuclear Gauge.*

10.4 *Scraper Plate and Drill Rod Guide.*

10.5 *Drill Rod and Driver or Hammer.*

10.6 *Shovel, Sieve, Trowel, or Straightedge and Miscellaneous Hand Tools.*

10.7 *Gauge Logbook.*

11. STANDARDIZATION

11.1 To standardize the nuclear density gauge, turn on the apparatus and allow it to stabilize.

Note 5—Follow the manufacturer's recommendations to ascertain the most stable and consistent results.

11.2 Perform standardization with the apparatus located at least 25 ft. (8 m) away from other sources of radioactivity. Clear the area of large masses or other items that may affect the reference count rate.

Note 6—The preferred location for standardization checking is the pavement location tested. This is the best method for determining day-to-day variability in the equipment.

11.3 Take a minimum of four repetitive readings using Table 2 at the normal measurement period, and determine the average of these readings.

Note 7—One measurement period of four or more times the normal period is acceptable if available on the apparatus. This constitutes one standardization check.

11.4 Detect the total number of gammas during the period by determining the count per measurement period. Correct the displayed value for any prescaling built into the instrument. Record this corrected value as N_s.

Note 8—The prescale value (F) is a divisor, which reduces the actual value for the purpose of display. The manufacturer will supply this value if other than 1.0.

11.5 Use the value of N_s to determine the count ratios for the current day's use of the instrument.

Note 9—Perform another standardization check if for any reason the measured density becomes suspect during the day's use.

11.6 Table 2 lists the required actions to take based on the results from Section 11.3.

Table 2
Reference Standard

If . . .	Then. . .
the value obtained is within the limits stated in limits calculation	the apparatus is considered to be in satisfactory operating condition and the value may be used to determine the count ratios for the day of use.
the value is outside these limits	allow additional time for the apparatus to stabilize, make sure the area is clear of sources of interference, then conduct another standardization check.
the second standardization check is within the limits	the apparatus may be used.
the second standardization check also fails the test	the apparatus must be adjusted or repaired as recommended by the manufacturer.

12. CALCULATIONS

12.1 Use the test results from Section 11.3 and the following calculations to determine the limit:

$$(N_s - N_o) \leq 2.0\sqrt{N_o / F}$$

Where:

N_s = value of current standardization count

N_o = average of the past four values of N_s taken previously

F = value of any prescale.

13. PROCEDURE

13.1 To determine the in-place density using a nuclear density gauge, select an area that is relatively free of loose material, voids, or depressions. Avoid elevating the gauge above the surface of the material to be tested.

Note 10—Select an area at least 12 in. (0.3 m) away from surface obstructions such as curbing, etc. It is optional to use fine sand to fill any voids or minor depressions.

13.2 Measure the density of the selected area in either the backscatter or direct transmission mode.

Note 11—The direct transmission method is only applicable for lifts greater than two in. (50 mm) thick.

13.3 Follow the instructions in Sections 13.3.1–13.3.2 to measure the in-place density of compacted bituminous pavements using a nuclear density gauge in the backscatter mode.

13.3.1 Firmly seat the density gauge on the selected area so it is in full contact with the surface.

13.3.2 Record the readings that are required at each location with the probe in the backscatter position. Do not leave the gauge in one position on the compacted bituminous pavement for a long time, as erratic readings may result from the hot surface. Proceed to Section 13.5.

13.4 Follow the instructions in Sections 13.4.1–13.4.4 to measure the in-place density of compacted bituminous pavements using a nuclear density gauge in the direct transmission mode.

13.4.1 Make a hole two in. (50 mm) deeper than the transmission depth used with the drive pin and guide plate.

Note 12—The hole must be as close as possible to 90° from the plane surface.

13.4.2 Firmly seat the density gauge on the prepared area so it is in full contact with the surface.

13.4.3 Adjust the probe to the desired transmission depth. Pull the gauge so that the probe is in contact with the side of the hole nearest the detector tubes.

13.4.4 Measure and record the readings required for each location for the particular type of gauge used. Proceed to Section 13.5.

13.5 Use one of the following methods to determine the in-place density.

13.5.1 Divide the field counts by the standard counts.

OR

13.5.2 Use the appropriate calibration curves, if necessary.

Note 13—Most models are now programmable to provide direct reading of the nuclear density or percent compaction.

13.6 Take cores or sections of the pavement from the same area selected for the nuclear tests when correlating the nuclear density to the actual density of the compacted material.

13.7 Measure the G_a of the cores or samples taken from the selected area tested for density as described in Part I or Part VI. Establish a correlation factor using a minimum of seven core densities and seven nuclear

densities. Adjust the nuclear density readings using this correlation factor to correlate with the actual G_a determined through laboratory testing.

Note 14—When testing thin lifts in the backscatter mode, the influence of underlying strata with varying densities may render this procedure impractical without special planning. Most manuals for the nuclear gauge describe the various methods to use with thin lifts.

13.8 Make correlations as described in Section 13.6 and compare the correlated nuclear density to the G_r or G_{rc} of the mixture when controlling in-place density with the nuclear gauge. Calculate the percent density or directly read from programmable models to determine air-void content.

PART IV—ESTABLISHING ROLLER PATTERNS (CONTROL STRIP METHOD)

14. SCOPE

14.1 Use this procedure to establish roller patterns for bituminous pavement.

15. APPARATUS

15.1 *Nuclear Density Gauge.*

15.2 *Electrical Impedance (Nonnuclear) Density Measurement Gauge* (Optional).

15.3 *Portable Reference Standard.*

15.4 *Calibration Curves for the Nuclear Gauge.*

15.5 *Scraper Plate and Drill Rod Guide.*

15.6 *Drill Rod and Driver or Hammer.*

15.7 *Shovel, Sieve, Trowel, or Straightedge and Miscellaneous Hand Tools.*

15.8 *Gauge Logbook.*

16. PROCEDURE

16.1 To establish roller patterns (control strip method), refer to the gauge manufacturer's instructions for operating the density gauge.

Note 15—Standardize the equipment at the start of each day's use as described in Part III when using a nuclear density gauge.

Note 16—Operate electrical impedance (nonnuclear) gauges in continuous mode to ensure all data is from the location in question.

16.2 Establish a control strip approximately 300 ft. (90 m) long and at least 12 ft. (3.5 m) wide or the width of the paving machine. Select three test sites.

Note 17—Avoid areas near edges or overlap of successive passes of the rollers.

16.3 Allow the roller to complete a minimum of two coverages of the entire control strip before checking the density. Perform density tests at the three test sites selected. Record the results. Mark each test site very

carefully so that subsequent tests made are in the same position and location. Use a colored marker keel to outline the gauge before taking the readings. Take the tests as quickly as possible and release rollers to complete additional coverage to prevent cooling of unrolled areas.

16.4 Repeat the density tests at the previously marked test sites. Continue this process of rolling and testing until there is no significant increase in density. Try several different combinations of equipment, and numbers of passes with each combination, to determine the most effective rolling pattern.

Note 18—In-place density determined with roadway cores is the final measure of rolling pattern effectiveness.

16.5 Construct another section, without interruption, using the roller patterns and number of coverages determined by the control strip after completion of the control strip tests. Take random density tests on this section to verify the results from the control strip.

Note 19—It may be possible to reduce the required coverages based on these tests.

16.6 Make density tests for job control in accordance with the *Guide Schedule of Sampling and Testing* or as often as necessary, when some changes in the compacted material indicate the need.

17. NOTES

17.1 Visual observation of the surface being compacted is a very important part of this procedure. Cease rolling and get an evaluation of the roller pattern if obvious signs of distress develop, such as cracking, shoving, etc. Structural failures due to over-compaction will cause the density tests to indicate the need for more compaction. Observe closely and take particular care when using vibratory rollers, since they are more likely to produce over-compaction in the material.

17.2 Use the minimum test time allowed by the particular gauge when measuring density on hot material, since the gauge may display erratic results if overheated.

17.3 Exercise particular care to clean the bottom of the gauge after using it on asphalt pavement.

17.4 Use the correlation procedures outlined in Part III, Section 13.7 when using specified density and rolling patterns with a nuclear density gauge.

17.5 This procedure provides a general guide to establish roller patterns. Follow the manufacturer's instruction manual furnished with the particular density gauge for specific operation of that gauge. This is essential, since several different models and different brands are in standard use by the Department.

17.6 Nuclear gauges and the user of the nuclear gauges must meet all requirements of the Department's radioactive material license, "Nuclear Gauge Operating Procedures," and the *Texas Rules for Control of Radiation*.

PART V—DETERMINING MAT SEGREGATION USING A DENSITY-TESTING GAUGE

18. SCOPE

18.1 Use this procedure to identify segregation in bituminous pavements after placement on the roadway using a density-testing gauge.

19. APPARATUS

19.1 *Nuclear Density Gauge.*

19.2 *Thin Lift Density Gauge* (Optional).

19.3 *Electrical Impedance (Nonnuclear) Measurement Gauge* (Optional).

19.4 *Measuring Tape* (Optional).

20. REPORT FORMS

20.1 Use Segregation Density Profile Form to identify segregation in a pavement section.

21. PROCEDURE

21.1 Refer to the manufacturer's instructions for operating the density gauge.

Note 20—It is not necessary to calibrate the gauge to the mix.

Note 21—Operate electrical impedance (nonnuclear) gauges in continuous mode to ensure all data is from the location in question.

21.2 Profile a 50 ft. (15 m) section of the bituminous pavement.

21.3 When profiling a location where the paver stopped for more than 60 sec., perform the instructions in Sections 21.3.1–21.3.3.

21.3.1 Identify the location where the paver stopped paving, such as sporadic mix delivery.

21.3.2 Move approximately 10 ft. (3 m) behind the location where the paver stopped paving, and mark and record this location as the beginning of the profile section.

21.3.3 Proceed to Section 21.6.

21.4 When profiling a random location, randomly select an area, and then choose an area with visible segregation, if possible. Proceed to Section 21.6.

21.5 When profiling an area with segregation of longitudinal streaking greater than the profile length, perform the instructions in Sections 21.5.1–21.5.5.

21.5.1 Profile the area at an angle in a diagonal direction.

21.5.2 Start the profile with a transverse offset of 2 ft. (0.6 m) from the center of the longitudinal streak.

21.5.3 End profile with a transverse offset of 2 ft. (0.6 m) on the opposite side of the longitudinal streak.

21.5.4 Do not start or end a profile less than 1 ft. (0.3 m) from the pavement edge.

21.5.5 Proceed to Section 21.7.

21.6 Determine the transverse offset 2 ft. (0.6 m) or more from the pavement edge. Take density readings in a longitudinal direction and do not vary from this line. Visually observe the mat and note the surface texture in

the section and the location of any visible segregated areas. Take additional readings along the transverse offset in areas with visible segregation. Include any visually segregated areas in the profile.

21.7 After completion of the final rolling patterns, position the density gauge at the identified location.

21.7.1 *Use of a Nuclear Density Gauge:*

21.7.1.1 Take three one min. readings (minimum time length, longer readings can be used) in backscatter mode when using a nuclear density gauge at each random sample location.

21.7.1.2 It is optional to use fine sand passing the No. 40 sieve size to fill any voids without elevating the gauge above the rest of the mat.

21.7.2 *Use of an Electrical Impedance Gauge:*

21.7.2.1 Take two readings; it is not necessary to move the gauge between readings.

Note 22—Operate electrical impedance (nonnuclear) gauges in continuous mode to ensure all data is from the location in question.

21.8 Record the in-place density gauge readings.

21.9 Average the readings before moving the density gauge. Compare each individual reading to the average. Discard any single readings that vary more than 1 pcf (16 kg/m^3) from the average. Take additional readings to replace the discarded readings until all the readings are within 1 pcf (16 kg/m^3) of the average.

21.10 Move the density gauge approximately 5 ft. (1.5 m) forward in the direction of the paving operation. Take an additional set of readings at any location with visible segregation in between the 5 ft. (1.5 m) distance.

21.11 Repeat the instructions in Sections 21.7–21.10. Complete a minimum of 10 sets of readings.

Note 23—Use a nuclear density gauge to verify impedance gauge readings whenever readings from an impedance gauge may not be accurate.

21.12 Determine the average density from all locations.

21.13 Determine the difference between the highest and lowest average density.

21.14 Determine the difference between the average and lowest average density.

21.15 Record the data using the Example Segregation Profile Worksheet.

PART VI—BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES USING THE VACUUM METHOD

22. SCOPE

22.1 Use this procedure to determine the G_a of compacted bituminous mixtures using the vacuum device. This procedure is applicable for mixtures with more than 2.0% water absorption.

23. APPARATUS

23.1 *Specialized Vacuum Sealing Device.*

23.2 *Balance,* Class G2 in accordance with Tex-901-K, minimum capacity of 10,000 g, equipped with suitable apparatus to permit weighing of the specimen while suspended in water.

23.3 *Suspension Apparatus, Non-Absorptive String, Metal Bucket, or Cage,* attached to the balance with a metal wire or a non-absorptive string.

23.4 *Mercury Thermometer,* marked in 2°F (1°C) divisions or less, or digital thermometer, capable of measuring the temperature specified in the test procedure.

23.5 *Water Bath with a Tank Heater and Circulator,* for immersing the specimen in water while suspended from a scale, equipped with an overflow outlet for maintaining a constant water level.

23.6 *Vacuum Device,* such as Coredryer (optional).

23.7 *Measuring Device,* such as a ruler, calipers, or measuring tape.

24. TEST SPECIMENS

24.1 Test specimens may be laboratory-molded mixtures or pavement cores.

24.2 Avoid distorting, bending or cracking the specimens during and after removal from pavements or molds. Store the specimens in a cool place.

24.3 Obtain cores in accordance with Tex-251-F, Part I.

24.4 *Laboratory-Molded Specimens:*

24.4.1 Measure and record the specimen height to the nearest 1/16 in.

24.5 *Pavement Cores:*

24.5.1 Prepare pavement cores for testing in accordance with Tex-251-F, Part II.

25. MATERIALS

25.1 Use a supply of large and small-specialized polymer bags as recommended by the manufacturer.

26. PROCEDURES

26.1 *Vacuum Sealing Device Setup:*

26.1.1 Set the vacuum timer.

Note 24—The manufacturer calibrates the vacuum pump timer setting and exhaust at the factory to eliminate drift and variability due to the sealing process. The vacuum pump operates for approximately one min. Contact the manufacturer for adjustments if the vacuum pump stops before this time has elapsed.

26.1.2 Set the sealing bar timer in accordance with the vacuum device manufacturer's recommendations.

Note 25—Inspect the seal quality after the first sealing operation. Reduce the setting if the polymer bag stretches or burns. Increase the setting if the seal is not complete or the bag easily separates.

26.2 *Determine the G_a of Compacted Bituminous Mixtures:*

26.2.1 Perform the instructions in Sections 26.2.2–26.2.3 for specimens containing moisture. Proceed to Section 26.2.4 for laboratory-molded specimens.

26.2.2 Proceed to Section 26.2.3 or, as an option, pre-dry the specimen using a Coredryer or air dry to remove excess moisture.

26.2.3 Place the specimen in an oven with the flat side of the specimen on a flat surface. Oven-dry the specimen for a minimum of two hr. at a temperature of 115 ± 5°F (46 ± 3°C) to a constant weight. "Constant weight" is the weight at which further oven drying does not alter the weight by more than 0.05% in a two hr. or longer drying interval in accordance with Section 7.1. Refer to Part I, Notes 3 and 4.

26.2.4 Allow the specimen to cool to room temperature, and then weigh in air to the nearest 0.1 g. Record and designate this weight as *A* in Section 27.1.

26.2.5 Open the lid of the vacuum device. Stack or remove rectangular spacer plates in the vacuum chamber of the vacuum device so there is adequate space for the test specimen.

26.2.6 Place a sliding plate in the vacuum chamber on top of the spacer plates away from the seal bar.

Note 26—Place the sliding plate in the chamber to reduce friction during the sealing operation.

26.2.7 Select and use a large or small polymer bag, as recommended by the manufacturer, to seal the specimen.

26.2.8 Weigh the selected polymer bag and record and designate this weight as *B* in Section 27.1.

26.2.9 *Determine the Polymer Bag Correction Factor (CF):*

26.2.9.1 Calculate the ratio, R, by dividing the weight of the specimen by the weight of the bag.

26.2.9.2 Use the CF Table provided in the manufacturer's operator guide.

26.2.9.3 Look up the calculated R-value and record and designate the corresponding correction factor from the table as *CF* in Section 27.1.

26.2.10 *Vacuum Seal the Specimens:*

26.2.10.1 Place the bag inside the chamber.

26.2.10.2 Place the specimen in the polymer bag, carefully avoiding puncturing or tearing the bag.

26.2.10.3 Center the core in the bag, leaving approximately 1 in. (25.4 mm) of slack on the backside.

26.2.10.4 Position the bag so that approximately 1 in. (25.4 mm) of the open end is evenly against the sealing bar.

26.2.10.5 Close the lid of the vacuum device and hold firmly for two to three sec.

Note 27—The vacuum pump will start, and the lid will stay closed on its own. The vacuum gauge will read less than 28 in. (50 mm) Hg.

26.2.10.6 The lid of the vacuum device will automatically open upon completion of the sealing process. Carefully remove the sealed specimen from the chamber. Gently pull on the polymer bag to ensure the seal is tightly conformed to the specimen. Return to the instructions in Section 26.2.8 if the seal is not tightly conformed to the specimen.

Note 28—A loose seal may be an indication of a leak.

26.2.11 Determine the type of apparatus to use to weigh the samples suspended in water.

26.2.12 Unplug or turn off the water circulator in the water bath while obtaining the submerged sample weight. Attach the apparatus to the scale and submerge in water. Tare the scale with the apparatus submerged in water.

26.2.13 Completely submerge the sealed specimen in water at 77 ± 3°F (25 ± 2°C) and record the weight of the specimen in the bag. Weigh the sealed specimen in water. Record the weight to the nearest 0.1 g when the scale reading stabilizes. Designate this weight as *C* in Section 27.1.

Note 29—Do not allow the polymer bag to touch the sides of the water bath.

26.2.14 Remove the specimen from the polymer bag and reweigh the specimen in air. Compare this weight to the weight recorded for *A* in Section 26.2.4. If the difference in weight is greater than 5 g, a leak may have occurred. Dry the sample to a constant weight and repeat the procedure using a new polymer bag.

26.3 Do not use the test results calculated in this test procedure using the vacuum device if this method produces a G_a that is higher than the G_a calculated in Part I.

Note 30—Use the results calculated in Part I of this method in this case.

27. CALCULATIONS

27.1 Calculate the G_a of the compacted specimen:

$$G_a = \frac{A}{\left[\left(A+B\right)-C\right]-\frac{B}{CF}}$$

Where:

G_a = bulk specific gravity,

A = weight of specimen in air, g,

B = weight of the polymer bag in air, g,

C = weight of sealed specimen in water, g, and

CF = correction factor.

PART VII—DETERMINING LONGITUDINAL JOINT DENSITY USING A DENSITY-TESTING GAUGE

28. SCOPE

28.1 Use this procedure to perform a longitudinal joint density evaluation on bituminous pavement using a density-testing gauge.

29. APPARATUS

29.1 *Nuclear Density Gauge.*

29.2 *Thin Lift Density Gauge* (Optional).

29.3 *Electrical Impedance (Nonnuclear) Density Measurement Gauge* (Optional).

29.4 *Measuring Tape* (Optional).

30. FORMS

30.1 Longitudinal Joint Density Profile Form.

31. PROCEDURES

31.1 *Perform a Longitudinal Joint Density Using a Density-Testing Gauge:*

31.1.1 Refer to the manufacturer's instructions for operating the density gauge.

31.1.2 Identify the random sample location selected for in-place air void testing. Mark and record this location as the reference point to perform the joint evaluation.

Note 31—This point must be more than 2 ft. (0.6 m) from the pavement edge.

31.1.3 Position the gauge at the random sample location selected for in-place air void testing identified in Section 36.1.2 after completion of the final rolling pattern.

31.1.3.1 *Use of a Nuclear Density Gauge:*

31.1.3.1.1 Take three one min. readings (minimum time length, longer readings can be used) in backscatter mode when using a nuclear density gauge.

31.1.3.1.2 It is optional to use fine sand passing the No. 40 sieve size to fill any voids without elevating the gauge above the rest of the mat.

31.1.3.2 *Use of an Electrical Impedance Gauge:*

31.1.3.2.1 Take two readings; it is not necessary to move the gauge between readings.

Note 32—Operate electrical impedance (nonnuclear) gauges in continuous mode to ensure all data is from the location in question.

31.1.4 Record the density measurements from the density gauge at the random sample location selected for in-place air void testing.

31.1.5 Measure the longitudinal joint density at the right and left edge of the mat, which is or will become a longitudinal joint.

Note 33—Select a location that is perpendicular to the random sample location selected for in-place air void testing.

Identify the joint type as "Confined" or "Unconfined."

Note 34—Take additional readings along the longitudinal joint at areas with visible irregularities or segregation.

31.1.6 Position the gauge with the center placed 8 in. (200 mm) from the pavement edge that is or will become a longitudinal joint. Orient the gauge so the longer dimension of the gauge is parallel to the longitudinal joint.

31.1.6.1 *Use of a Nuclear Density Gauge:*

31.1.6.1.1 Take three one min. readings (minimum time length, longer readings can be used) in backscatter mode when using a nuclear density gauge.

31.1.6.1.2 It is optional to use fine sand passing the No. 40 sieve size to fill any voids without elevating the gauge above the rest of the mat.

31.1.6.2 *Use of an Electrical Impedance Gauge:*

31.1.6.2.1 Take two readings; it is not necessary to move the gauge between readings.

Note 35—Operate electrical impedance (nonnuclear) gauges in continuous mode to ensure all data is from the location in question.

31.1.7 Record the density measurements from the density gauge at the longitudinal joint.

31.1.8 Determine the difference in density between the readings taken at the random sample location selected for in-place air void testing and the readings taken at the longitudinal joint.

Note 36—Use a nuclear density gauge to verify impedance gauge readings whenever readings from an impedance gauge may not be accurate.

31.1.9 Record and report the data using the Example Longitudinal Joint Density Worksheet.

31.2 *Determine a Correlated Joint Density:*

31.2.1 Record the average G_a of the cores taken at the random sample location selected for in-place air voids (*A*).

31.2.2 Record the G_r for each sublot evaluated for joint density (*B*).

31.2.3 Record the average density gauge reading in pcf (kg/m^3) at the longitudinal joint sample location for in-place air voids (*C*).

31.2.4 Record the average density gauge reading in pcf (kg/m^3) at the interior mat random sample location for in-place air voids (*D*).

31.2.5 Record and report the data using the Example Longitudinal Joint Density Worksheet.

32. CALCULATIONS

32.1 Calculate the correlated joint density, CJD (%) of the compacted specimen:

$$CJD(\%) = \frac{A}{B} \times \frac{C}{D} \times 100$$

Where:

A = Average G_a of cores at random sample location,

B = Rice gravity, G_r, for each sublot,

C = Average density gauge reading at the longitudinal joint, pcf (kg/m^3), and

D = Average density gauge reading at the interior mat sample location, pcf (kg/m^3).

PART VIII—DETERMINING DENSITY OF PERMEABLE FRICTION COURSE (PFC) AND THIN BONDED WEARING COURSE (TBWC) MIXTURES

33. SCOPE

33.1 Use this procedure to back-calculate the G_r of loose PFC and TBWC mixtures, to calculate the G_a of laboratory-molded specimens for PFC and TBWC mixtures using dimensional analysis, and to calculate density of compacted PFC and TBWC mixtures.

34. APPARATUS

34.1 *Measuring Device,* such as a ruler, calipers, or measuring tape.

35. PROCEDURE

35.1 Back calculate G_r.

35.1.1 Obtain the G_e of the combined aggregate blend.

Note 37—Obtain the G_e from the Summary worksheet of the Mix Design Template.

35.1.2 Record and designate this as G_e in Section 36.1.

35.1.3 Determine the AC of the PFC or TBWC mixture.

Note 38—Determine the AC of PFC-Asphalt Rubber (AR) mixtures by using the asphalt flow meter. Determine the AC of PFC PG 76 mixtures using an ignition oven in accordance with Tex-236-F or by using the asphalt flow meter

35.1.4 Record and designate this as A_s in Section 36.1.

35.1.5 Determine the specific gravity of the asphalt binder. Round to three decimal places (0.001).

35.1.6 Record and designate this as G_s in Section 36.1.

35.1.7 Calculate G_r as noted in Section 36.1.

35.2 Calculate G_a using dimensional analysis.

35.2.1 Measure the weight of the laboratory molded specimen in air, to the nearest 0.1 g.

35.2.2 Record and designate this weight as W in Section 36.2.

35.2.3 Measure the height of the laboratory-molded specimen, to the nearest 0.1 mm.

35.2.4 Record and designate this height as h in Section 36.2.

35.2.5 Measure the diameter of the laboratory-molded specimen, to the nearest 0.1 mm.

Note 39—The diameter for specimens molded with a Superpave Gyratory Compactor is 150 mm.

35.2.6 Calculate the radius of the laboratory-molded specimen by dividing the diameter, as determined in Section 34.2.5, by 2.

Note 40—The radius for specimens molded with a Superpave Gyratory Compactor is 75 mm.

35.2.7 Record and designate this as *r* in Section 36.2.

35.2.8 Calculate G_a as noted in Section 36.2.

Note 41—Numerical value for π is 3.14.

35.3 Calculate density of compacted PFC or TBWC mixture.

35.3.1 Divide the G_a determined in Section 35.2.8 by the G_r determined in Section 35.1.7.

35.3.2 Multiply the results from Section 35.3.1 by 100.

Note 42—Round this calculated value to the tenth decimal place (0.1).

36. CALCULATIONS

36.1 Calculate the G_r of the loose PFC or TBWC mixture:

$$G_r = \frac{100}{\left[\left(\frac{100 - A_s}{G_e}\right) + \left(\frac{A_s}{G_s}\right)\right]}$$

Where:

G_r = theoretical maximum specific gravity,

G_e = effective specific gravity, %,

A_s = AC, %,and

G_s = asphalt binder specific gravity, 0.001.

36.2 Calculate the G_a of the compacted specimen:

$$G_a = \frac{\left[\frac{W}{\pi r^2 h}\right]}{\gamma}$$

Where:

G_a = bulk specific gravity,

W = weight of specimen, 0.1 g,

π = pi, 3.14,

r = radius of specimen, 1 mm,

h = height of specimen, 0.1 mm, and

γ = density of water, 0.001 g/mm^3.

37. REPORT FORMAT

37.1 Use the following Excel programs to calculate and report density test results.

37.1.1 Quality Control/Quality Assurance (QC/QA), used in conjunction with the hot mix specification and test data worksheets. Refer to the "Help" tab for detailed instructions on how to use the program.

37.1.2 Segregation Density Profile Form.

37.1.3 Longitudinal Joint Density Profile Form.

38. ARCHIVED VERSIONS

38.1 Archived versions are available.