

Virginia Test Method - 6

**Field Determination of Bulk Specific Gravity of  
Compacted Asphalt Mixtures Using Saturated  
Surface Dry Specimens**

**October 1, 2008**

**1. Scope**

- 1.1 This method of test covers the field determination of bulk specific gravity of compacted asphalt mixtures.
- 1.2 The bulk specific gravity of the compacted asphalt mixtures may be used in calculating the unit of mass of the mixture.
- 1.3 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

**2. Referenced Documents**

*ASTM D 7227 Standard Practice for Rapid Drying of Compacted Asphalt Specimens Using Vacuum Drying Apparatus.*

**3. Test Specimens**

- 3.1 Test specimens are from any course of asphalt pavements.
- 3.2 Size of specimen shall be as specified in VTM-22.

**4. Apparatus**

- 4.1 Balance: A 2000 gram balance with an accuracy of 1.0 gram. The balance shall be equipped with suitable suspension apparatus and holder to permit weighing the specimen while suspended from the center of scale pan of balance. (Note 1).

NOTE 1: The holder shall be immersed in water to a depth sufficient to cover it and the test sample during weighing. Wire suspending the holder should be the smallest practical size to minimize any possible effects of a variable immersed length.

- 4.2 Water Bath: For immersing the specimen in water while suspended under the balance.
- 4.3 Water used in water bath shall meet the requirements for water used with cement or lime in the Road and Bridge Specifications.

## 5. Procedure

- 5.1 Mass of dry specimen in air <sup>Note 2, 3, 4</sup> - Weigh the specimen in air. Designate this mass as “A”.
- 5.2 Mass of specimen in water - Immerse the specimen in water bath for a minimum of one minute and determine the weight. Designate this mass as “C”.
- 5.3 Mass of saturated surface dry specimen in air - Surface dry the specimen by blotting all sides quickly with a damp towel and then weigh in air. Designate this mass as “B”.

NOTE 2: Specimens removed by a process that does not use water will require no further drying.

NOTE 3: Samples saturated with water initially either from wet coring or other source of water shall be dried to a constant mass until further drying does not alter the mass by more than 0.1 percent.

Specimens shall be dried overnight at  $125 \pm 5^\circ\text{F}$  ( $52 \pm 3^\circ\text{C}$ ) and then weighed at two-hour intervals, or vacuum-dried in accordance with ASTM D7227, until constant mass is obtained.

NOTE 4: If desired, the sequence of testing operations may be changed to expedite the test results. For example, first the immersed mass (C) can be taken, then the surface dry mass (B), and finally the dry mass (A).

When the sequence of testing operations is changed, the method outlined in Note 3 shall be used to the Dry Mass of the Specimen in Air (A) once the specimen has cooled to room temperature.

## 6. Calculation

- 6.1 Calculate the bulk specific gravity of the specimen as follows: (Report the value up to two decimal places.)

$$\text{Bulk Specific Gravity} = \frac{A}{B-C}$$

Where:

A = mass, in grams, of sample in air.

B = mass, in grams, of surface dry specimen in air.

C = mass, in grams, of sample of water.

## Virginia Test Method - 22

### Field Determination of Percent Density of Compacted Asphalt Concrete Mixtures

October 1, 2008

#### 1. Scope

This method covers the procedure for determining the percent density of compacted Asphalt Concrete mixtures in the field.

#### 2. Apparatus

2.1 Rotary saw or coring machine as specified in VDOT specifications or special provisions.

#### 3. Test Specimens

3.1 Two 4x4 in. sawed specimens shall be taken per site or two 4 in. (100 mm) diameter core specimens.

3.2 Care shall be taken to avoid distortion, bending or cracking of specimens during and after removal from the pavement.

3.3 To aid in cooling specimens, CO<sub>2</sub>, or dry ice is recommended for use prior to sawing and removing from the pavement.

3.4 If necessary, specimen may be separated from other pavement layers by sawing or other satisfactory means.

#### 4. Procedure

4.1 Measure thickness of test specimen.

4.2 Determine the bulk specific gravity of the specimen in accordance with VTM-6.

4.3 The initial theoretical maximum specific gravity of an asphalt concrete mixture may be the job-mix value determined at the job-mix asphalt content until the production value has been determined on the material being placed in accordance with AASHTO T-209.

NOTE: The initial theoretical maximum specific gravity value shall be verified by the District or Central Office laboratory.

4.4 For dense graded asphalt concrete mixes (i.e. SUPERPAVE™ mixes), the theoretical maximum specific gravity used as the denominator for the percent density calculation shall be determined by a moving average of five values based on the contractor's test results.

For stone matrix asphalt concrete mixes, the theoretical maximum specific gravity used as the denominator for the percent density calculation shall be determined by using the simple of average of the contractor's daily production test results. Only the theoretical maximum specific gravity used shall be a simple average.

4.5 Until five values are obtained from the contractor's testing, the theoretical maximum specific gravity used shall be a simple average.

**5. Calculation**

5.1 Calculate the percent density of each site as follows:

$$\text{Percent Density} = \frac{\text{Average Bulk Specific Gravity}}{\text{Theoretical Maximum Specific Gravity}} \times 100$$

Where the Average Bulk Specific Gravity is either the average of the two specimens per site or the average bulk specific gravity of the total sites being evaluated, report to 3 decimal places.

**6. Report**

6.1 Report depth to nearest 0.1 inch (3 mm).

6.2 Report percent density of each test specimen to nearest 0.1 percent.

**7. Precision**

7.1 If the difference in the bulk specific gravity between two specimens from the same test site varies by more than 0.045, discard and obtain two more specimens from a new test site.

7.2 If the difference in theoretical maximum specific gravity between the VDOT monitor sample and the contractor sample varies by more than 0.019 per AASHTO T-209, then the results (VDOT and contractor) shall not be used in the calculation of percent density unless testing error is identified. If testing error is identified, then VDOT will determine which maximum theoretical specific gravity result to use in the percent density calculation.

**Virginia Test Method – 76**  
**Control Strip Density And Roller Pattern**  
**And Control Strip Procedure Using A Thin-Lift**  
**Nuclear Density Gauge For Asphalt Concrete Mixtures**

**October 1, 2008**

**1. Scope**

- 1.1 This method details the establishment of the minimum control strip density using the Thin-Lift Nuclear Gauge and a recommended procedure for setting up the Control Strip/Roller Pattern. Other procedures for setting up the Control Strip/Roller Pattern may be used when approved by the Engineer.
- 1.2 Within the first 500' to 1000' (150 m to 300 m) of mix placement a Roller Pattern and Control Strip will be constructed. The first 75' (25 m) (approximate) length will be the Roller Pattern, and the next 300' (100 m) (approximate) length will be the Control Strip, regardless of the paver width, and should be of the same depth or application rate as called for in the plans and/or contract.  
  
\*Note : A Roller Pattern and Control Strip should only be constructed after a minimum of 500' (150 m) of mix has been placed.
- 1.3 The Roller Pattern and Control Strip shall be constructed using the same material, the same paving equipment and in the same manner as the remainder of the project.
- 1.4 To prevent delay in Density Determination, cores/plugs from surface and intermediate mixes shall be cut using a dry method of sawing. Cores/plugs from base mixes may be cut using either a dry method or a wet method of sawing.
- 1.5 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

**2. Apparatus**

- 2.1 Approved Mix Design
- 2.2 Approved Paving Equipment
- 2.3 Nuclear Gauge Template and white/other approved spray paint
- 2.4 Thin-Lift Nuclear Density Gauge with printer, must meet requirements of VTM-81
- 2.5 Magnesium Nuclear Gauge Calibration Block

- 2.6 A rolling measuring device that will measure from 1 to 1000 linear feet (1-300 meters), or any other device approved by the Engineer
- 2.7 Rotary Saw or Coring machine for sawing a core/plug.
- 2.8 Equipment to weigh cores/plugs (VTM-6)
- 2.9 All apparatus to be furnished by the Contractor
- 2.10 The Maximum Theoretical Specific Gravity as determined in VTM-22.

### 3. Procedure

- 3.1 At the beginning of each day a standard count check of the nuclear gauge should be performed at the project site.
- 3.2 To begin the Roller Pattern, make several passes (up and back) on 75' (25 m) (approximate) of one section of the paver width. Move the roller over and roll the same number of passes on the other section of the paver width. (Refer to sketches in section 4.3) Record the number and type of Roller passes placed on the asphalt mat on the Asphalt Nuclear Density Roller Pattern Worksheet.

\*Note: Use judgement and experience to make the maximum number of passes before beginning the nuclear gauge readings. (ex. If a mix has historically taken 6 vibratory passes of the roller to achieve compaction, then 4 vibratory passes should be made on the roller pattern section before any nuclear density readings are recorded. If there were no prior experience with a specific type of mix, then 2 passes (one (1) up and one (1) back) would be recommended as a starting point.) The Roller Pattern should be constructed in the same manner and with the same compaction equipment that the rest of the pavement will be constructed. If the paver width is wider than 12' (4 meters) and a breakdown roller will take more than two roller widths to get coverage over the entire mat then the roller pattern should reflect the procedure that will be used in production.

- 3.3 Select three (3) locations to be tested for density in the 75' (25 m) roller pattern area. Two (2) locations shall be approximately 30' (9 meters) apart on one side of the lane and one (1) location on the opposite side of the lane approximately 15' (5 meters) from each of the first two sites. The exact location the gauge is placed shall be marked. The Nuclear Gauge shall always be positioned parallel with the roadway, with the source end toward the direction of the paver anytime a reading is taken. To prevent erroneous readings, care must be taken to ensure that the gauge is sitting flat on the asphalt surface and does not rock. Care must also be taken by the gauge operator to ensure that the gauge's source is in the proper test position when readings are taken. Nuclear readings for the Roller Pattern shall be taken using the 30-second mode. Tests will be taken after each additional pass from the same three (3) locations, with the gauge sitting in the same position as the first test. It is recommended that the paver stop while the roller pattern is being constructed. Once the roller pattern has been established the control strip will be placed using the same process except the paver will not pause or stop.

- 3.4 The average of the three (3) readings shall be plotted on the Roller Pattern Graph, in Density, lb/ft<sup>3</sup> or kg/m<sup>3</sup>, vs. number of passes. The Roller Pattern shall be rolled until maximum density for the asphalt mixture is obtained. To achieve maximum density, the mat shall be rolled until the average density reading decreases. After the first decrease, the mat shall receive one additional pass of the roller to ensure that this was not a false break. If the mat continues to decrease in density, then the maximum density will be the density achieved one roller pass before the initial decrease in density.

If a false break occurs (the density increases on the additional pass), then continue to make roller passes until the density decreases a second time. Once the density has decreased, make an additional pass. If the density decreases on this pass, then the maximum density will be the density achieved one roller pass before the second decrease. If the density increases, repeat these steps until maximum density has been achieved.

**Note: Typically a decrease in density of 0.5 lb/ft<sup>3</sup> (0.25 kg/m<sup>3</sup>) will indicate that maximum density has been achieved.**

- 3.5 Build a 300' (100 m) Control Strip by following the procedure established in the 75' (25 m) Roller Pattern section. Ten stratified random selected locations will be marked in the 300' (100 m) Control Strip section with the Nuclear Gauge Template (Section 4.3 – Figure 2). The template shall be placed on the mat and positioned parallel with the roadway with the arrows pointing in the direction of the paver. The Template shall be spray painted with white/other approved paint such that the underlying pavement is marked with paint through the cutouts in the template. These locations must be clearly visible when the template is removed. After marking its location with paint the Gauge Template shall be removed and a number painted near the site (not within the template's boundary).
- 3.6 The Nuclear Gauge (the special calibration and offset modes will be disabled and set in the one (1) minute mode for testing) shall then be placed within the area marked by the Gauge Template with the source toward the direction of the paver. Nuclear density readings in lb/ft<sup>3</sup> (kg/m<sup>3</sup>) using the one-minute mode will be taken at the ten (10) locations marked in the 300' (100 m) Control Strip section. The average of the ten (10) nuclear density tests, in lb/ft<sup>3</sup> (kg/m<sup>3</sup>) will become the target density if the average bulk density of the cores/plugs determined in this Control Strip is satisfactory.
- 3.7 One set of plugs/cores (two 4" x 4" sawed plugs or two 4" diameter cores) (2-100 mm x 100 mm sawed plugs or 2-100 mm diameter cores) shall be taken for density determination from three of the ten nuclear gauge reading locations in the 300' (100 m) Control Strip section. The sites for the sawed plugs/cores should be the three sites that are the closest to the average nuclear gauge target density established in Section 3.6. The plugs/cores shall be taken within the gauge template's boundary directly beneath where the nuclear source of the gauge was located. Compute the bulk density of the 6 plugs/cores (VTM-6). If one plug/core from a site is damaged, then the remaining undamaged plug/core will represent the bulk density of that specific site. If both plugs are damaged, then another set of plugs will be taken from the next site whose nuclear density reading

is closest to the target density. The average bulk density for each site will be determined. The percent density (VTM-22) will be calculated from the three average bulk densities determined at each site. If the average percent density of the three sites meets density requirements of Section 315 of the Road and Bridge Specifications the average nuclear density determined in Section 3.6 will become the Target Density, in lb/ft<sup>3</sup> (kg/m<sup>3</sup>).

3.7.1 Lift Thicknesses 2.5" (63 mm) and Less - Artificial and rapid cooling methods (such as dry ice and CO<sub>2</sub>) are used to chill fresh warm mats sufficiently to dry saw/core the mat for density testing without damaging the sample. Note, use of flammable materials such as propane shall not be used as a rapid cooling method.

3.7.2 Lift Thicknesses In Excess of 2.5" (63 mm) - Wet cooling methods may be used to obtain density plugs/cores on lift thicknesses in excess of 2.5" (63 mm). When wet cooling is used, the cores/plugs must be dried back in the lab and VTM-6 followed to determine the percent density. Artificial and rapid cooling methods are not effective. When wet cooling methods are not used, a period of not less than 12 hours after placement of the mix must pass before density plugs/cores are obtained. Note, use of flammable materials such as propane shall not be used as a rapid cooling method.

- 3.8 When the same approved mix design is to be used on a roadway other than the one for which the cores/plugs were taken for density determination, a new 375' (125 m) (approx.) Roller Pattern/Control Strip shall be constructed to determine the Roller Pattern and Target Density for this roadway. The Roller Pattern/Control Strip for this roadway will be determined in the same manner as the original with the exception that only one set (2 sawed plugs/cores) shall be taken from one of the ten nuclear gauge reading locations in the 300' (100 m) Control Strip section. The site for the plugs/cores should be the site that the nuclear density reading is closest to the target density established in Section 3.6. The average bulk density for the site will be determined. The percent density (VTM-22) will then be calculated from the average bulk density. If the percent density meets specification, the average of ten (10) nuclear readings taken at random locations from the stratified 300' (100 m) (approx.) section shall become the Target Density, in lb/ft<sup>3</sup> (kg/m<sup>3</sup>), for this roadway.

3.8.1 Lift Thicknesses 2.5" (63 mm) and Less - Artificial and rapid cooling methods (such as dry ice and CO<sub>2</sub>) are used to chill fresh warm mats sufficiently to dry saw/core the mat for density testing without damaging the sample. Note, use of flammable materials such as propane shall not be used as a rapid cooling method.

3.8.2 Lift Thicknesses In Excess of 2.5" (63 mm) - Wet cooling methods may be used to obtain density plug/cores on lift thicknesses in excess of 2.5" (63 mm). When wet cooling is used, the plugs/cores must be dried back in the lab and VTM-6 followed to determine the percent density. Artificial and rapid cooling methods are not effective. When wet cooling methods are not used, a period of not less than 12 hours after placement of the mix must pass before density plugs/cores are obtained. Note, use of flammable materials such as propane shall not be used as a rapid cooling method.

#### **4. Report**

- 4.1 The calculations to determine the percent of Target Density obtained for each lot shall be recorded in the project notebook and used to determine any pay adjustment.
- 4.2 The forms recommended for use with this test method include, but are not limited to, TL-56, TL-57, TL-58, TL-59, TL-60, and TL-60A.

### 4.3 Sketches of Roller Pattern/control Strip

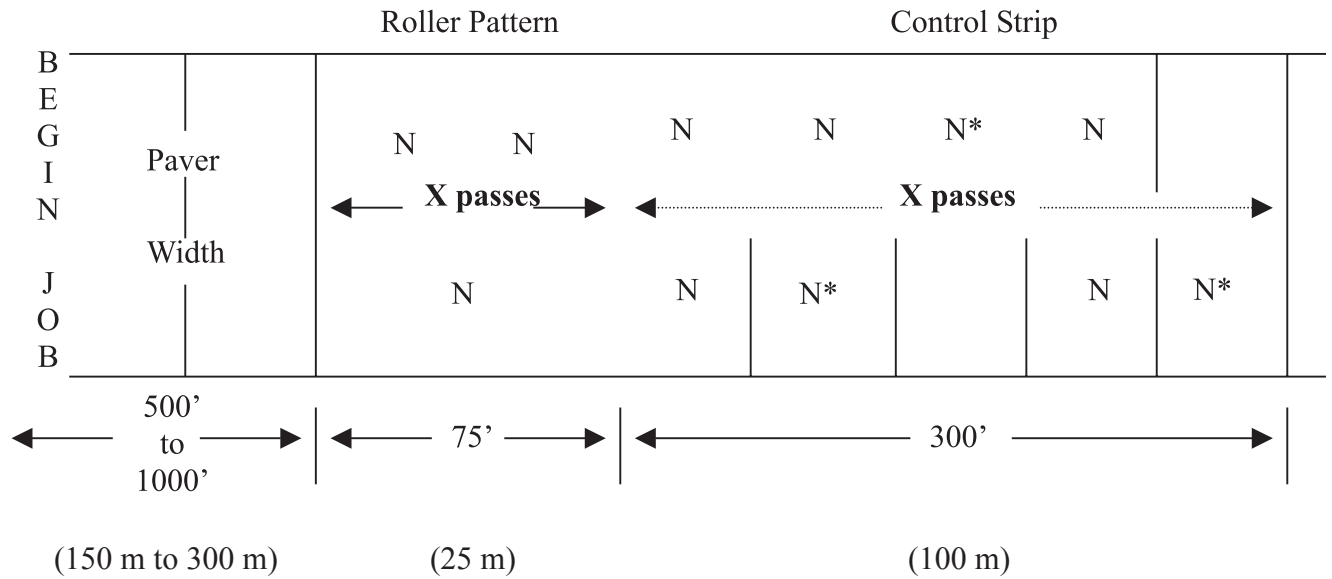


Figure 1

- X = Number of passes by roller
- N = Location of Nuclear Readings (Must be selected by random method and sites marked with template before taking readings.)
- \* = Location of Cores/Plugs(Three sites closest to target density.)

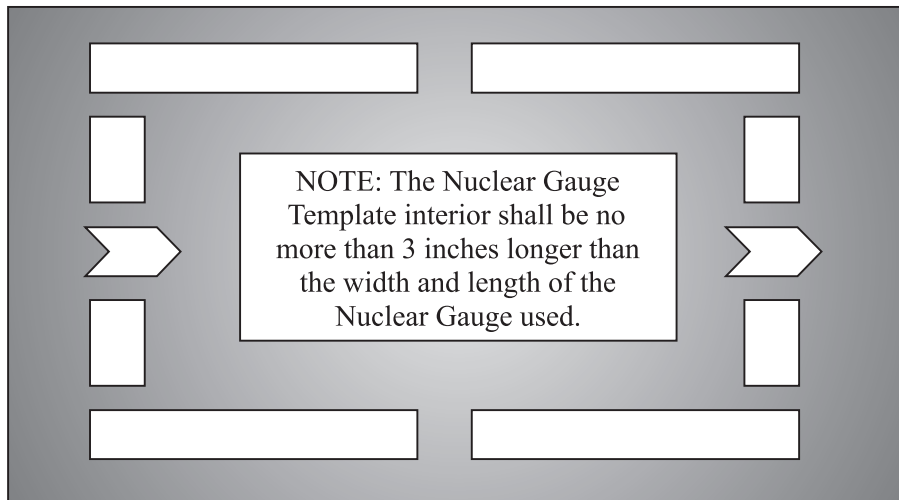
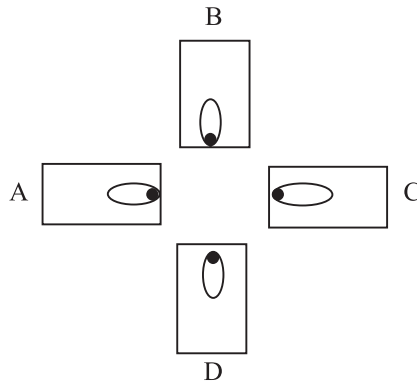


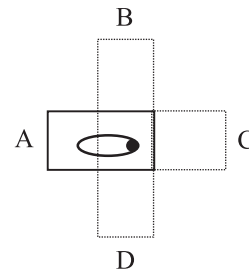
Figure 2. Nuclear Gauge Template

## 5. Nuclear Density vs Core/plug Density

5.1 When making any comparison of a core/plug density with that of a Nuclear Gauge Density, the Nuclear Gauge Density shall be an average of four (4) readings taken from the core/plug density, as shown in one of the sketches shown below. Also, if a comparison is to be made of any nuclear Density Reading sites, then each site should be an average of four (4) reading taken from each site location in the manner as shown in the sketch below for a core/plug site.



Gauge positions for comparison to a cut core/plug



Gauge positions for comparisons over a core/plug site

- Source