

**APPENDIX D**

**VIRGINIA TEST METHODS**



## Virginia Test Method – 1

### Laboratory Determination of Theoretical Maximum Density Optimum Moisture Content of Soils, Granular Subbase, and Base Materials (Soils Lab)

June 13, 2013

AASHTO T 99 Method A shall be followed, except as modified below:

#### 12. Moisture Density Relationship

Note 12a: If there is 10% or greater material retained on the No. 4 (4.75 mm) sieve, use the following corrective procedure for determining the theoretical maximum dry density and optimum moisture content.

#### Material Containing Plus No. 4 (4.75 mm) Sieve Particles

AASHTO T 99 Method A procedure is applicable to soil that contains little or no material retained on the No. 4 (4.75 mm) sieve. Since the maximum density curve determined in the laboratory is obtained by utilizing only that material passing the No. 4 (4.75 mm) sieve, any appreciable amount of larger material contained in the embankment, which is being checked for compaction, will increase the apparent density, due to the higher specific gravity of the stone as compared to the bulk gravity of the compacted dry soil. At the same time, the optimum moisture content will be less, because some of the material passing the No. 4 (4.75 mm) sieve is replaced with coarser material (the void space is reduced and the total surface area is decreased).

(1) The theoretical maximum density, "D" of mixtures containing coarse aggregate larger than a No. 4 (4.75 mm) sieve will be determined by the formula:

$$D = \frac{D_f \times D_c}{(P_c \times D_f) + (P_f \times D_c)}$$

Where:

$D_f$  = Maximum dry laboratory density of minus No. 4 material (by AASHTO Designation: T 99), in lb/ft<sup>3</sup>

$D_c$  = Maximum density of Plus No. 4 material (62.4 lb/ft<sup>3</sup> x bulk specific gravity by AASHTO Designation: T85 or as estimated by the Engineer), in lb/ft<sup>3</sup>

$P_c$  = Percent plus No. 4 material, expressed as a decimal, and

$P_f$  = Percent minus No. 4 material, expressed as a decimal or by nomograph (see Figure 1).

- (2) The optimum moisture for the total soil will be determined by the formula:

$$W_t = (P_c W_c + P_f W_f) 100$$

Where:

$W_t$  = Optimum moisture content for total soil,

$W_c$  = Optimum moisture content (absorption), expressed as a decimal, for material retained on No. 4 sieve (estimated between 1% and 3%),

$W_f$  = Optimum moisture content, expressed as a decimal, for material passing No. 4 sieve,

$P_c$  = Percent, expressed as a decimal, of material retained on a No. 4 sieve, and

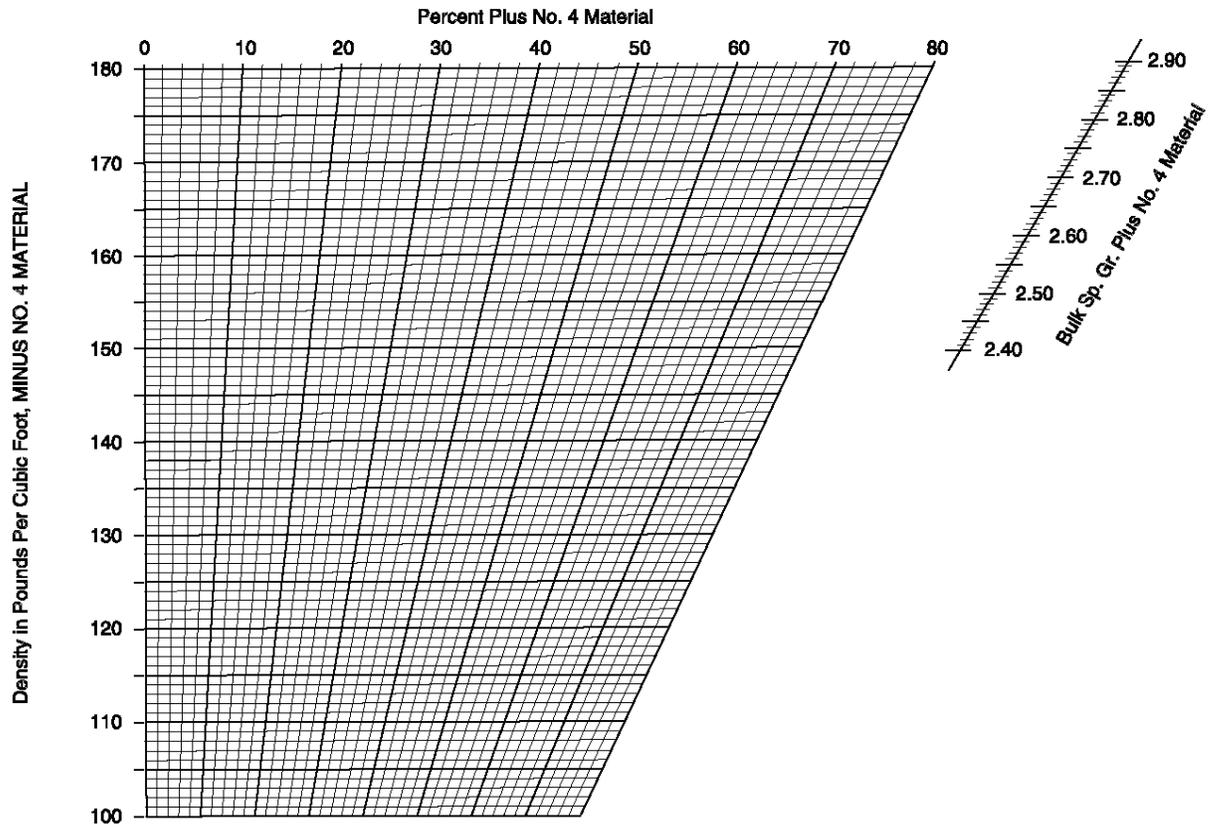
$P_f$  = Percent, expressed as a decimal, of material passing a No. 4 sieve.

**General Notes:**

1. The density required in the work will be a variable percentage of the theoretical maximum density, "D", depending upon variations in the percentage of plus No. 4 material in the mixture and upon the position of the material in the work, and will be specified in the applicable section of the specifications.
2. The District Materials Engineer will inform the Inspector of the results of the compaction tests on the minus 4 material and the specific gravity of the +4 material. With this information, the Inspector can then prepare a chart showing the density of the total sample for varying percentages of the +4 material.
3. When performing this test on #10 tertiary screenings (stone dust), be guided by the unique recommendations for field compaction as stated in the Materials Division Manual of Instructions, Section 309.06."

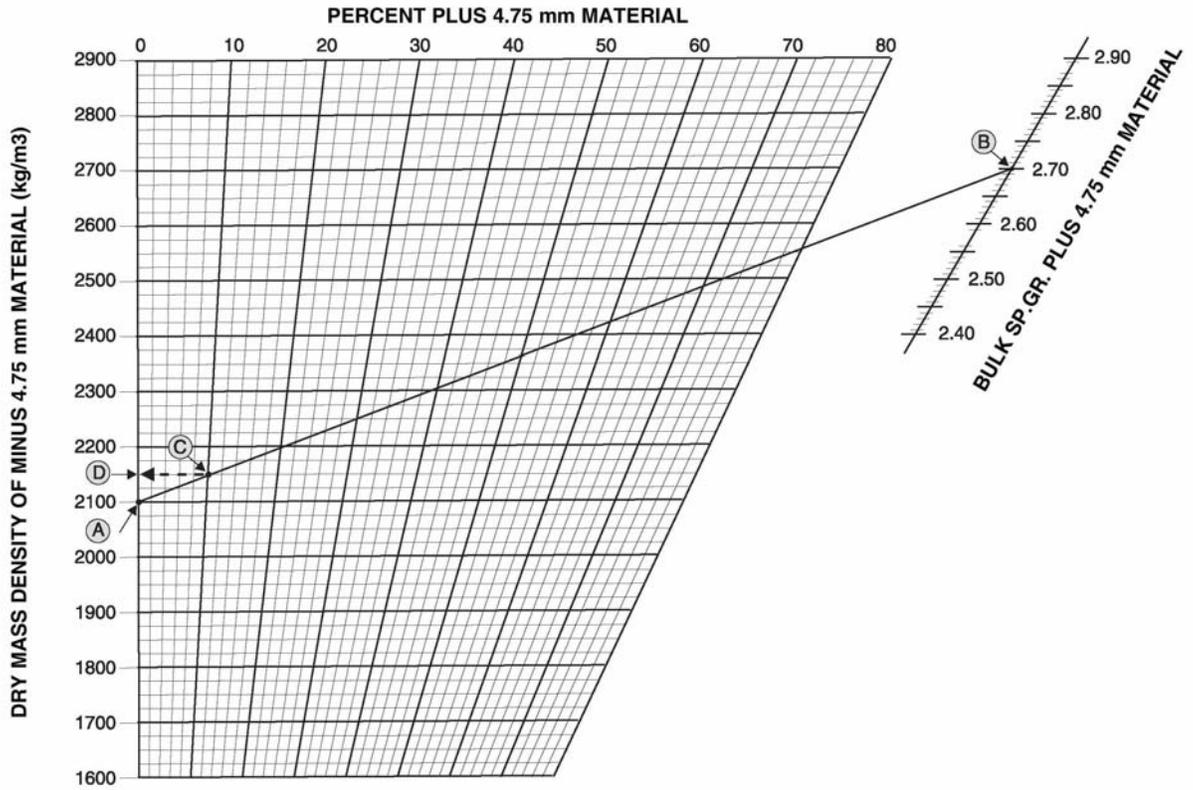


# NOMOGRAPH FOR DETERMINING TOTAL DENSITIES OF SOILS





# NOMOGRAPH FOR DETERMINING TOTAL DENSITIES OF SOILS



## Virginia Test Method – 10

### Determining Percent of Moisture and Density of Soils, Aggregate, and Full-Depth Reclamation Courses, and Density of Cold In-Place Recycling and Cold Plant Recycling (Nuclear Method – Soils Lab)

June 25, 2013

AASHTO T 310 shall be followed, except as modified below:

#### 3. Scope

This test method covers the procedure to be used in determining the percent of moisture and density of embankment, base, subbase, subgrade, backfill, and Full-Depth Reclamation (FDR) courses, and the percent density of Cold In-Place Recycling (CIR) and Cold Plant Recycling (CPR).

#### 4. Apparatus

The apparatus required shall consist of the following:

- A. Portable Nuclear Moisture-Density Gauge (nuclear gauge or gauge)
- B. Transport case (blue)
- C. Charger
- D. Reference Standard Block
- E. Transport Documents (Bill of Lading)
- F. Leveling Plate / Drive Pin Guide
- G. Drive Pin w/ extraction tool
- H. 4 lb Hammer used for Driving the Pin
- I. Safety Glasses
- J. Square-Point Shovel
- K. No. 4 (4.75 mm) sieve
- L. Set Balance Scales
- M. Drying Apparatus
- N. Miscellaneous Tools such as Mixing Pans and Spoons

#### 5. Direct Transmission and Backscatter Procedures

There are two (2) different methods to determine percent density and percent moisture using the nuclear gauge. The methods are the direct transmission and backscatter.

The direct transmission method requires punching a hole into the surface of the material being tested and lowering the source rod to the desired depth of test. This method is used to test natural soil materials, aggregate backfill, FDR, CIR, and CPR courses, and as verification testing for aggregate base and subbase as it is more representative over the compacted layer than the backscatter method. It is also used as acceptance testing for those projects not having a sufficient quantity of aggregate base and/or subbase to run a roller pattern and control strip.

In the backscatter method the source rod is lowered to the first notch below the safe position placing the source and detectors in the same horizontal plane. No hole is required for the probe since it is flush with the bottom of the gauge. This method is used to test aggregate (subbase and base course) and asphalt materials. When testing soils, the backscatter position **shall not** be used as a means of acceptance for density.

**6. Moisture-Density Determination for Embankment, Subgrade, and Backfill (Direct Transmission Method)**

All nuclear gauge density tests on embankment, subgrade, backfill, FDR, CIR, and CPR courses using the nuclear gauge shall be tested using the Direct Transmission Method. This is because embankment, subgrade, and structure backfill (except aggregate pipe backfill) are typically comprised of natural soils that can be readily tested by Direct Transmission, and Full-Depth Reclamation courses are treated similarly. The method is as follows:

1. Establish an area at least ten feet from any structure and 33 ft. from other radioactive sources (another gauge) to take standard counts. This area can be concrete, asphalt, or a well compacted soil with a minimum dry density of 100 lb/ft<sup>3</sup>. Do not use truck beds, tailgates, tabletops, etc. When using the nuclear gauge, turn it on and wait for it to perform its self-test. When it is completed the gauge will enter the "Ready" mode. At this time, standard counts can be taken and recorded.

**Note:** A standard count will be taken each day of use. If counts fail, refer to the gauge's Manual of Operations and Instructions for further instructions or call your VDOT District Materials Section for assistance.

2. Level off an area of the embankment or subgrade on which to place the gauge using the leveling plate furnished with the gauge. The surface of this area should be as smooth as possible to obtain an accurate test. Care should be taken not to additionally compact the surface during its preparation.
3. Place the guide plate on the surface. Make a hole in the material with the driving pin provided, using the guide plate to be sure the hole is straight and vertical. The hole should extend approximately two (2) inches deeper than the desired test depth.
4. Extend the source rod just enough to place it in the hole in order to avoid soil disturbance around the hole. Then, after the minimal initial insertion, extend the rod to the desired depth of test making sure the device is sitting flush on the surface and the rod is pulled back tight against the backside of the hole. Take a one-minute count in this position.
5. The test is complete and the results are recorded on Form TL-124A.

If the material tested is represented by a predetermined Proctor Test (VTM-1 or VTM-12, which give the theoretical maximum density), the dry density (corrected for +4 oversize material when necessary) should be entered into the gauge prior to testing. This allows the gauge to calculate the percent of compaction.

When it is apparent that the material being placed is different from the material that is specified, due to noticeable changes in color, texture, rock size, etc., another Proctor Test may need to be made on the new material.

In the event the material contains appreciable amounts retained on the No. 4 sieve (greater than 10%, per VTM-1), the Proctor Test Density used shall be the corrected density. This corrected density is typically already furnished by the testing laboratory, but the gauge operator must ensure the corrected density is being used. (Not doing so is one of the most common errors made when testing field density.)

If the material being placed is determined to be “rock fill” an entry must be recorded on the TL-124A form, showing location and elevation of rock.

Direct Transmission testing of aggregate will be required in rare instances when the embankment, subgrade, or backfill material (except pipe backfill which is always aggregate to the springline and in some cases above that) is comprised not of natural soil but of a dense-graded aggregate, such as 21A or B or a dense-graded aggregate select material. Dry density of aggregate material shall always be compared to the theoretical maximum dry density as determined by VTM-1 or VTM-12. When Direct Transmission testing is performed on these occasions, because of the difficulty of driving the pin through dense-graded aggregate and the disturbance of the hole it causes, the density shall conform to the following requirements in Table I, which are reduced by 5% from the requirements for aggregate that may be tested by other means of less disturbance. These reduced densities in Table I also apply to natural soil embankment, subgrade, and backfill with greater than 50% retained on the No. 4 sieve.

**Table I**  
**Reduced Density Requirements for Direct Transmission Testing of Aggregate**

% Retained on No. 4 (4.75 mm) Sieve*	Minimum % Dry Density
0 – 50	95
51 – 60	90
61 – 70	85

\* Percentages of material shall be reported to the nearest whole number.

**5. Moisture-Density Determination for Aggregate Base and Subbase (Backscatter Method)**

Aggregate base and subbase are tested by means of a roller pattern, control strip, and test sections. The backscatter method is used with the nuclear gauge when testing aggregate base and subbase courses and asphalt, because of the difficulty of driving a pin through these materials. (However, a direct transmission test on aggregate base and subbase courses is made to verify densities as described in Note 1 in Paragraph B below.)

The Roller Pattern is performed first. The purpose is to determine the number of passes to be made by the roller in various combinations of static and/or vibratory rolls to achieve the maximum density for that depth of material using that roller. The data collected from the gauge is entered on the TL-53A form. Properly plotted, this will provide a graphical comparison of the number of roller passes necessary to produce a properly compacted product. Once completed this information is used to establish a Control Strip(s).

The Control Strip determines the target values for density that will define the acceptance criteria for the material placed and compacted using the previously determined roller pattern. The values determined by the control strip will not change until a new roller pattern is required. The data collected is to be entered on the TL-54A form. The Control Strip provides an accurate method of evaluating materials, which are relatively uniform and exhibit smooth surfaces.

#### A. Roller Pattern

The Roller Pattern is constructed on the same material being placed and once established, will be used for the remainder of the project. The Roller Pattern is 75 ft in length plus some additional area to accommodate the lateral positioning of the roller. The width and depth of the material depends on the project design.

Listed below are the steps used to construct a Roller Pattern:

1. Establish an area at least ten feet from any structure and 33 ft. from other radioactive sources (another gauge) to take standard counts. This area can be concrete, asphalt, or a well compacted soil with a minimum dry density of 100 lb/ft<sup>3</sup>. Do not use truck beds, tailgates, tabletops, etc. When using the nuclear gauge, turn it on and wait for it to perform its self-test. When it is completed the gauge will enter the "Ready" mode. At this time, standard counts can be taken and recorded.

**Note:** A standard count will be taken each day of use. If counts fail, refer to the gauge's Manual of Operations and Instructions for further instructions or call your VDOT district materials section for assistance.

2. To prepare a Roller Pattern, place the material on a section of roadway approximately 75 ft. in length for the typical application width (an area of at least 100 yd<sup>2</sup>), and at the proper loose depth before any rolling is started. (The Contractor should be allowed to place 100 ft. of material prior to the 75 ft. section for plant mix stabilization, adjustment, and compaction purposes, with testing to be conducted at the completion of the roller pattern.) The compaction is to be completed uniformly and in the same manner for the remainder of the job. (It is also recommended that a 50 ft. section be placed before and after the roller pattern section for positioning of the roller.)

The moisture content of aggregates should be kept as near optimum as possible throughout the rolling operation. Water must be added when needed to maintain optimum moisture in accordance with Section 308 and 309 of the Road and Bridge Specifications during the compaction process.

To speed up operations, select 15-second mode on the read-out panel and record the density and moisture readings. When testing the control strip and test section, select the 60-second mode for acceptance.

3. Make two (2) passes (one (1) pass is counted each time the roller crosses the test site) with the roller over the entire surface of the Roller Pattern. Make sure the previous passes have been completed over the entire surface before the next pass is started. The above test on aggregates shall be made at three randomly selected points within the area to be tested.

Choose points with good surface conditions and try to spread the three tests over most of the 75 ft. section, making sure not to place the gauge closer than 18 in. to an unsupported edge. Be sure to mark the exact location where the gauge is placed. (If using spray paint to mark the locations, do not spray the gauge with paint.) The gauge, when in use, shall always be positioned parallel with the roadway, with the source end toward the direction of the paver. Record these results on the Roller Pattern Form TL-53A and obtain the total and average for both moisture and density.

All further tests for the Roller Pattern must be made in the same three locations, with the gauge source rod pointing in the same direction as the first test. Plot the average dry density versus the number of roller passes on the graph.

4. Make additional passes with the roller over the entire surface of the Roller Pattern, and again obtain and record the three readings for density and moisture in the same location as the previous set of readings. Calculate the average from the readings and record them on the Form TL-53A. Continue the rolling and testing of the section until the Roller Pattern reaches its maximum density before decreasing or the curve levels off. To be certain this is a sufficient degree of compaction, make one additional roll over the entire surface and test again.

**Note 1:** The number of passes that are indicated do not necessarily have to be set at two (2) each time. It may be found that in some instances one (1) pass would be sufficient between readings, and, in other instances, three (3) or four (4) passes would be required. An accurate count of the required passes should be maintained and may vary, depending on subgrade conditions, roller efficiency, type of materials and moisture content.

**Note 2:** Regarding determination of Maximum Attainable Density with Roller Pattern/Control Strip Technique:

The Control Strip shall be rolled until maximum dry density for granular materials is obtained. Materials compacted to maximum density provide a solid platform on which to construct pavement. Materials at maximum density increase pavement load carrying capacity and pavement life; opportunities for future pavement distress will be greatly decreased if maximum density is achieved. These guidelines should be considered good construction practice, not as an addition to the VDOT Road and Bridge Specifications.

In brief, the change in density in a typical Roller Pattern, for example, on Aggregate Base Material, Type I, Size 21B, may look as shown below in Table II below:

**Table II**  
**Example Roller Pattern Density Readings**

Number of Passes	Change in Density, lb/ft <sup>3</sup>
4	+3.1
6	+2.1
8	+2.3
10	+0.9
11	+0.4

It can be seen from the above that continued rolling after ten (10) passes resulted in diminishing returns. This is typical for many Roller Patterns. Based on an analysis of this type, the following is recommended as a guideline for granular materials: In the event that the increase in dry density for a Roller Pattern on granular material is less than  $1 \text{ lb/ft}^3$ , one (1) additional pass shall be required.

Occasionally, there will be instances where a decrease in density rather than a small increase will occur. This usually occurs for two (2) reasons: a false break, where the density levels off well before maximum density is achieved, and over rolling. In this case, consideration should be given to the number of passes already made and the materials involved, making certain that the break occurring in the Roller Pattern curve is not greater than  $1.5 \text{ lb/ft}^3$ . When the break is greater than the above value, re-compact the material to the maximum dry density based on the peak of the roller pattern.

A new roller pattern should be established whenever there are multiple lifts of material or there is a change in the following:

Source of material

Compaction equipment

Visual change in subsurface conditions

Gradation or type of material

Portable Nuclear Density Gauge: When this occurs, only another Control Strip is to be performed.

Test section readings are significantly above the target values by more than  $8 \text{ lb/ft}^3$ . When this occurs review the items in this list. Ask the roller operator if they are doing anything other than the number of passes that was established in the roller pattern. If these things do not produce the reason, then perform another Control Strip.

#### **B. Control Strip**

1. To prepare a Control Strip, an additional 300 ft. of roadway is required extending from Roller Pattern area (same spreader box width at the same design depth). This area is to be rolled the same number of passes from the Roller Pattern.
2. In order to determine the maximum dry density of the Control Strip, ten (10) readings for density and moisture should be performed and recorded over the entire 300 ft. section. Calculate and enter the data on the TL-54A Form. The Target Values of 98% and 95% of the average dry density can now be determined. The dry density determined from the average of the Control Strip densities should compare within  $3 \text{ lb/ft}^3$  of the roller pattern's maximum dry density.

**Note 1: Upon completion of the control strip, perform a direct transmission test to verify that compaction has been obtained comparing the result to the theoretical maximum dry density**

obtained by VTM-1 or VTM-12. Refer to Table I above for the minimum percent dry density required.

### C. Test Sections

1. To complete a test section, five (5) readings are required. Each test section for aggregate base, subbase, and select materials will be one-half (1/2) mile in length per application width. The length of test sections for shoulders will be the same as the mainline. If possible, test alternating sides. Five (5) readings will be made on each test section for dry density and moisture for aggregate courses using the same method of test used on the Roller Pattern and Control Strip. Rolling is continued until none of the five (5) readings is less than 95% of the Control Strip density, and the average of the five (5) readings is equal to or greater than 98% of the Control Strip density. This does not apply to aggregate shoulder material, which requires an average density of  $95 \pm 2$  percentage points of the control density, with individual densities within  $95 \pm 5$  percentage points of the control density. No other test will be required, unless specified by the Engineer. When test section readings are significantly above or below the target values by more than  $8 \text{ lb/ft}^3$ , another Control Strip will be established.
2. When testing turn lanes, acceleration lanes, deceleration lanes, and crossovers, take two (2) or three (3) readings on each, whichever is needed, to complete the full test section.

**Note:** For sections of roadway less than 900 ft., the direct transmission method or other approved testing methods for density determinations may be used.

If obvious signs of distress are observed while rolling, cease rolling and evaluate the area of distress. Such signs include cracking, shoving, etc. Structural failures of the aggregate will cause the gauge to give an erroneous reading indicating more compaction is needed, when actually over-compaction is causing the failure. If this situation occurs, it should be brought to the attention of the VDOT district materials section for an evaluation.

### 6. Moisture-Density Determination for FDR, CIR, and CPR Courses (Direct Transmission Method)

FDR, CIR, and CPR courses require roller pattern and control strip determinations in the same manner as for aggregate base and subbase courses (Section 5 above), except that:

Density test locations shall be marked and labeled by the Contractor in accordance with the requirements of VTM-76.

The roller pattern and control strip shall not be used for density acceptance. These courses require density acceptance based on the maximum density from the approved mix design. Hence Part "C. Test Sections" of Section 5 above does not apply.

Where Section 5 requires backscatter method, direct transmission method shall be used for FDR, CIR, and CPR courses.

Where Section 5 refers to dry density, these courses require the recording of wet density. (Moisture content is determined from laboratory moisture tests, and the dry density obtained. However, in order to facilitate quicker dry density determinations, at the discretion of the District Materials Engineer on a project basis, a water content correction factor based on previous gauge readings or laboratory tests may be used.)

Where Section 5 refers to Standard Proctor tests (VTM-1 or VTM-12 or AASHTO T 99), these courses require use of the Modified Proctor test (AASHTO T 180).

For FDR, CIR, and CPR courses, the same guidelines as for granular materials should be used in Section 5 above, with the exception that after the increase becomes less than 0.5 lb/ft<sup>3</sup> per pass, one (1) additional pass shall be required. If the density does not increase by 1.0 lb/ft<sup>3</sup> with the additional pass, rolling should be discontinued.

## **7. Moisture and Trench Wall Offsets**

### Moisture Offsets

Moisture in certain soil properties containing high amounts of hydrogen rich compounds, such as ash, mica, organics, cement, boron and cadmium, will give inaccurate readings and as a result a moisture offset should be performed. The moisture offset should be a minus for ash, mica, organics and cement and a plus for boron and cadmium. See Page 5-4 in Troxler's Manual of Operation and Instruction for the 3440 Series gauge.

Other methods of determining moisture are the use of the Speedy Moisture Tester or the hotplate method.

### Trench Wall Offsets

When a 3440 Nuclear Moisture-Density Gauge is operated within 24 in. of a vertical structure, the density and moisture counts will be influenced by the structure.

Due to the moisture present in trench walls on occasion, a higher moisture reading will be observed when testing backfill materials around pipe, culverts, abutments, etc. It is necessary, therefore, to determine the "background" effect and apply this correction to the observed moisture count readings. The background correction count should be determined each day of testing and when trench wall conditions (distance from wall, moisture content, material composition, etc.) vary. See Page 5.8 in Troxler's Manual of Operation and Instruction for the 3440 Series gauge.

The procedure to determine the background effect and apply the necessary correction is as follows:

1. Take a standard count with the gauge on the standard block outside the trench and record these values.
2. Place the gauge on the standard block inside the trench in the testing area and select trench offset. The density and moisture trench offset constants will be calculated and stored. When the gauge is not being used for trench measurements, disable the offset.

## Virginia Test Method – 12

### Use of One-Point Proctor Density (Soils Lab)

February 24, 2012

AASHTO T 272 (Method A) shall be followed, except as modified below:

#### 4. Apparatus

Add the following to Section 4.1:

- a. Drying apparatus (MARTCP SA 1.3) or "Speedy" moisture tester (AASHTO T217).

#### 6. Procedure

6.3 Take a sample for moisture content determination by field stove method in accordance with MARTCP method SA 1.3. Use "Speedy" moisture tester, if available, except for heavy clays, in which case the field stove should be used. "Speedy" Tester shall be performed in accordance with AASHTO T 217, or the manufacturer's directions labeled on the instrument. Record the moisture content.

#### 14. Maximum Density and Optimum Moisture Content Determination

14.1 Results for wet density of the soil in pounds per cubic foot and moisture content shall be plotted on Typical Moisture Density Curves Set "C" (Figure 1).

- A. Correction for +No. 4 (4.75 mm) in the sample, if there is 10% or greater material retained on the No. 4 (4.75 mm) sieve.

The correction to be used for the +No. 4 (4.75 mm) material is determined by the following procedures:

- (1) Record the percent of +No. 4 (4.75 mm) material from density hole.
- (2) The theoretical maximum density, "D" of mixtures containing coarse aggregate larger than a No. 4 (4.75 mm) sieve will be determined by the formula:

$$D = \frac{D_f \times D_c}{(P_c \times D_f) + (P_f \times D_c)}$$

Where:

$D_f$  = Maximum dry laboratory density of minus No. 4 material (by AASHTO Designation: T 99), in lb/ft<sup>3</sup>

$D_c$  = Maximum density of Plus No. 4 material (62.4 lb/ft<sup>3</sup> x bulk specific gravity by AASHTO Designation: T85 or as estimated by the Engineer), in lb/ft<sup>3</sup>

$P_c$  = Percent plus No. 4 material, expressed as a decimal, and

$P_f$  = Percent minus No. 4 material, expressed as a decimal or by nomograph (see Figure 1).

(3) The optimum moisture for the total soil will be determined by the formula:

$$W_t = (P_c W_c + P_f W_f) 100$$

Where:

$W_t$  = Optimum moisture content for total soil,

$W_c$  = Optimum moisture content (absorption), expressed as a decimal, for material retained on No. 4 sieve (estimated between 1% and 3%),

$W_f$  = Optimum moisture content, expressed as a decimal, for material passing No. 4 sieve,

$P_c$  = Percent, expressed as a decimal, of material retained on a No. 4 sieve, and

$P_f$  = Percent, expressed as a decimal, of material passing a No. 4 sieve.

Alternatively, the corrected maximum dry density can be determined herein with the aid of Figure 2.

#### B. Percent Compaction

$$\text{Percent Compaction} = \frac{\text{Field Dry Density}}{\text{Maximum Dry Density}} \times 100$$

#### General Notes:

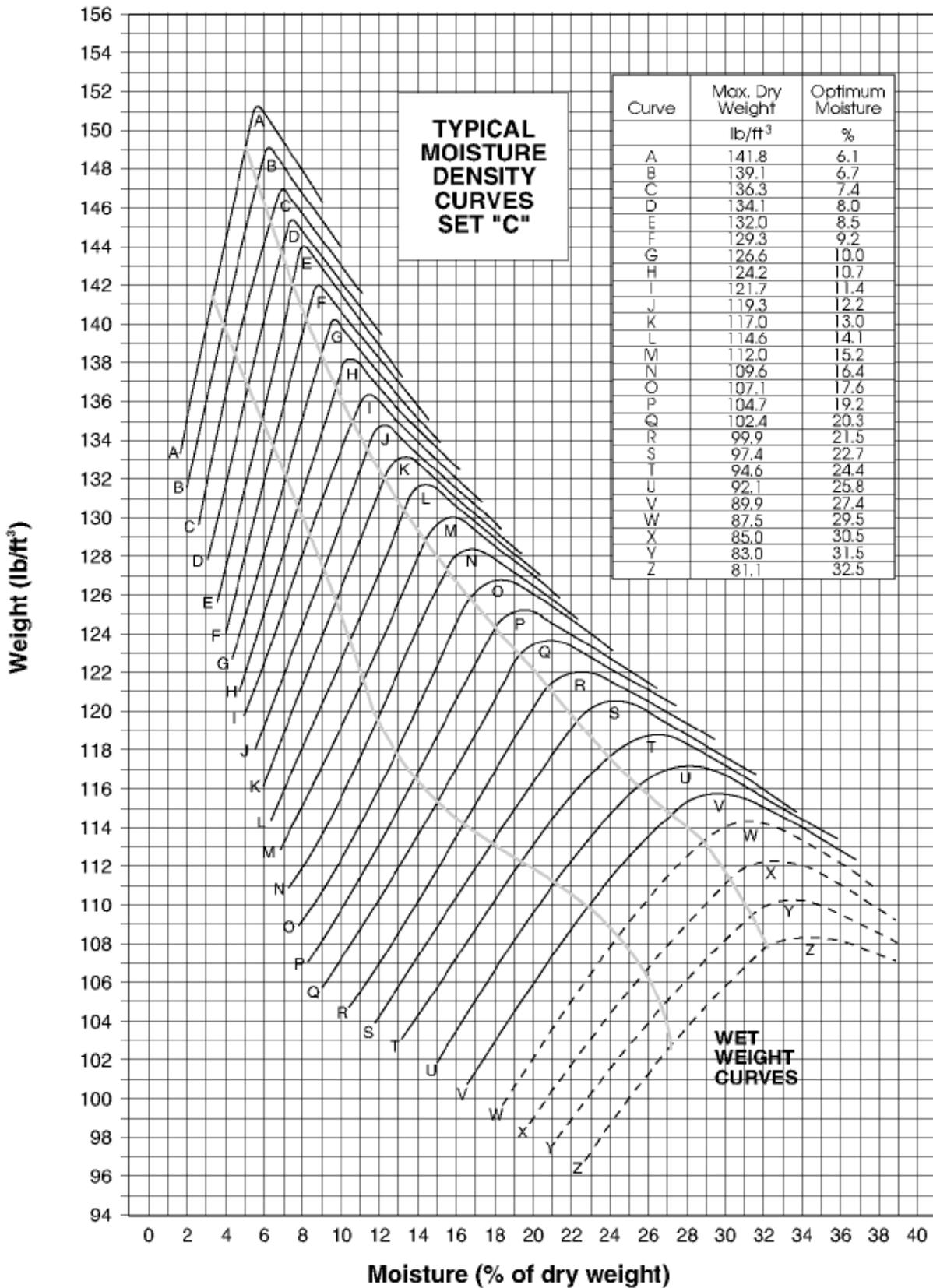
- 1 The density required in the work will be a variable percentage of the theoretical maximum density, "D", depending upon variations in the percentage of plus No. 4 (4.75 mm) material in the mixture and upon the position of the material in the work, and will be specified in the applicable section of the specifications.
- 2 The specific gravity of +4 material can be found in soil survey reports and contractor borrow material submittals for soils and Approved List No. 5 for aggregates.  
([http://www.virginiadot.org/business/resources/Materials/Approved\\_Lists.pdf](http://www.virginiadot.org/business/resources/Materials/Approved_Lists.pdf))

If this information is not available, the specific gravity can be assumed as directed by the District Material Engineer.

#### 14.3 Replace Note 4 with the following:

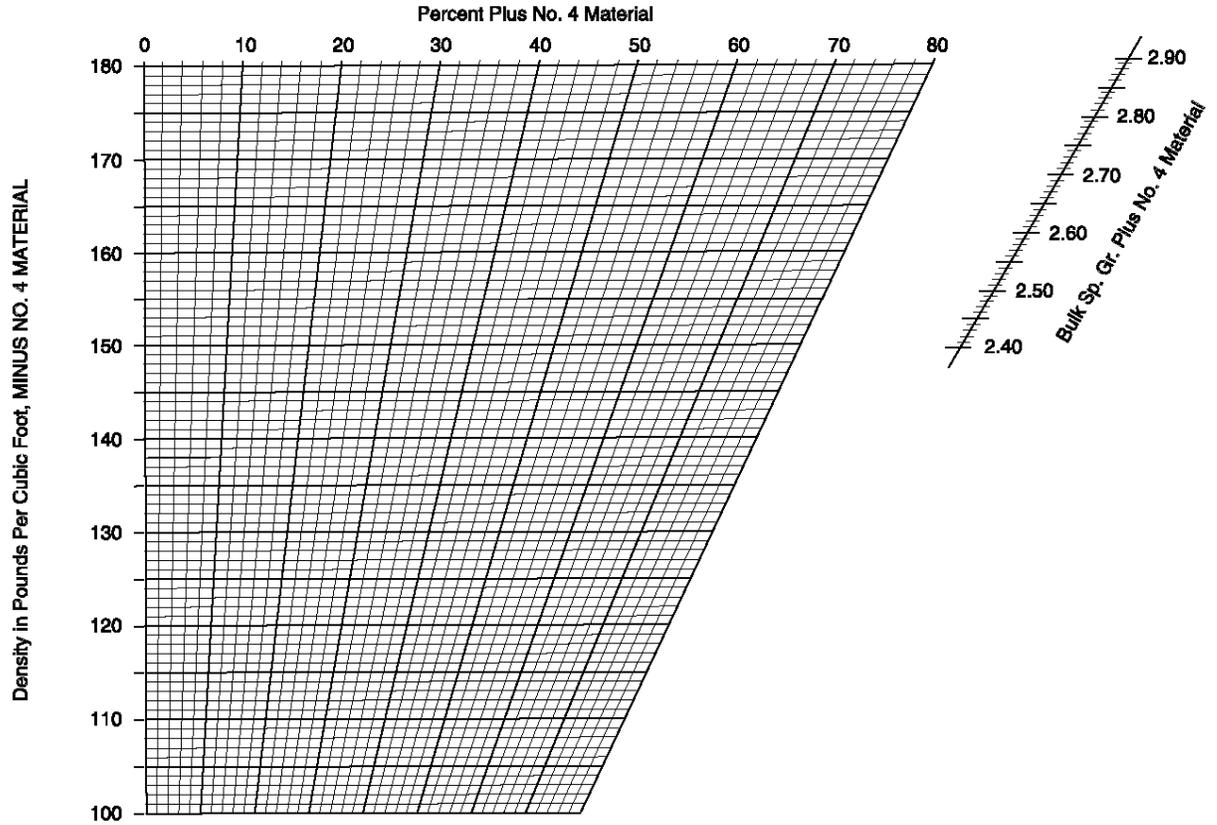
Note 4 - If the one point plotted within or on the family of curves (Figure 1) does not fall within the minimum and maximum curve range, compact another specimen, using the same material, at an adjusted moisture content that will place the one-point within this range.

ONE POINT PROCTOR



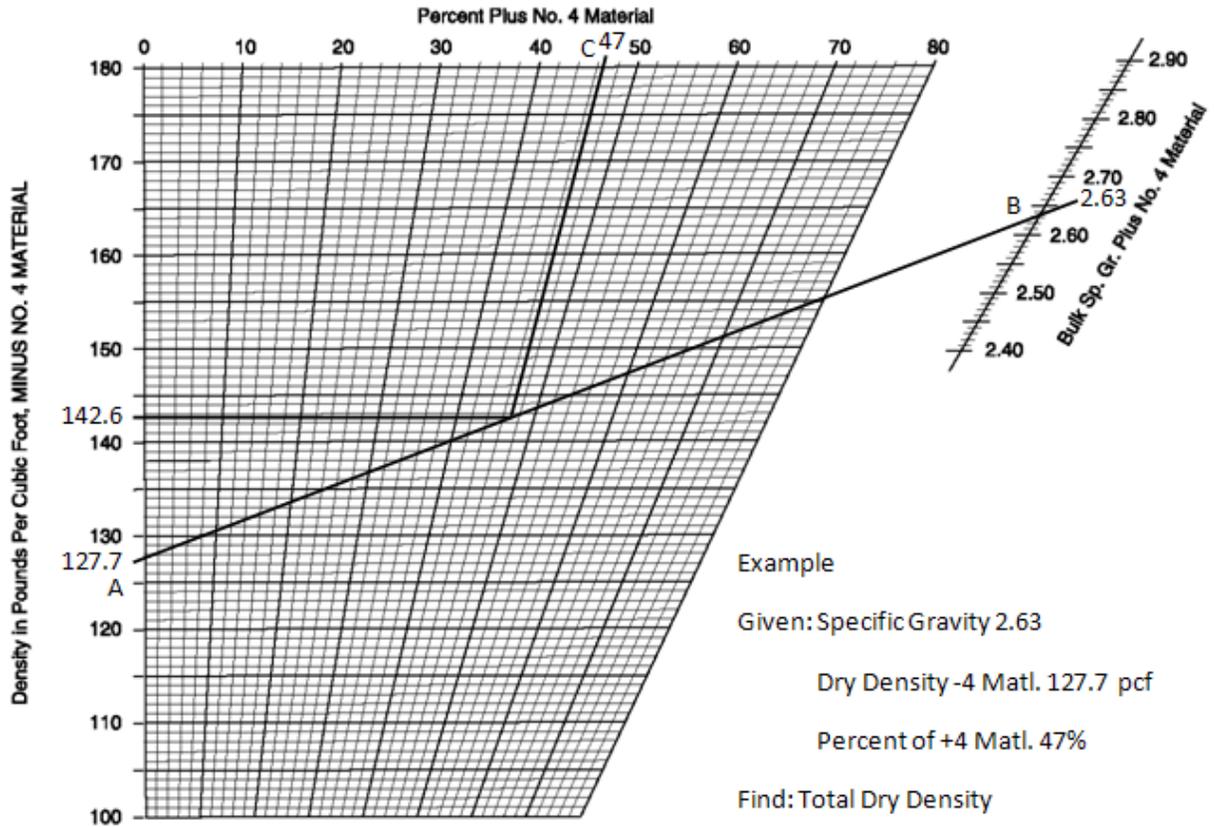


# NOMOGRAPH FOR DETERMINING TOTAL DENSITIES OF SOILS





# NOMOGRAPH FOR DETERMINING TOTAL DENSITIES OF SOILS



**Example**

Given: Specific Gravity 2.63

Dry Density -4 Matl. 127.7 pcf

Percent of +4 Matl. 47%

Find: Total Dry Density

1. Plot A, B and C
2. Using a straight edge draw a line from A to B
3. From C draw a line at the same slant as the nomograph lines to intersect line AB
4. Draw a straight line from the point of intersection to the left edge of the nomograph
5. Total Dry Density=142.6 pcf

**VIRGINIA TEST METHOD – 123****Post Installation Inspection of Buried Storm Drain Pipe and Pipe Culverts****June 25, 2010****SCOPE**

For all roadway projects that are constructed by private contractors for VDOT and for all roadway projects constructed by others that are or will be proposed to be accepted into the VDOT highway system, a visual/video camera post installation inspection is required on all storm sewer pipes and for a selected number of pipe culverts in accordance with the instructions contained in this VTM and Section 302.03 of the VDOT Road and Bridge Specifications. The video camera inspection is to be conducted with a VDOT representative present.

The inspection can be conducted manually if adequate crawl/walking space and ventilation is available to safely conduct the inspection and the individual(s) conducting the inspection have undergone training on working in confined spaces in accordance with VDOT's current Safety Policy and Procedure #8 Confined Space Entry Policy and Procedure - General, or the inspection can be conducted with a video camera. If the inspection is to be conducted with a video camera, the video camera shall have fully articulating lenses that will provide a 360 degree inspection of the pipe/culvert, including each joint and any deficient areas of the pipe/culvert, as well as a means to measure deformations/deflections of the pipe (items such as a laser range finder or other appropriate device for taking such measurements as specified herein and approved by the Engineer).

If the inspection is conducted manually, the person performing the inspection may use a standard video camera or a digital camera to document any observed deficiencies. If the mandrel test is to be performed to mechanically measure deformations/deflections of the pipe/culvert, the mandrel used shall be a nine (or greater odd number) arm mandrel, and shall be sized and inspected by the Engineer prior to testing. The diameter of the mandrel at any point shall not be less than the allowable percent deflection of the certified actual mean diameter of the pipe or culvert being tested. The mandrel shall be fabricated of metal, fitted with pulling rings at each end, stamped or engraved on some segment other than a runner with the nominal pipe/culvert size and mandrel outside diameter. The mandrel shall be pulled through the pipe or culvert by hand with a rope or cable. Where applicable, pulleys may be incorporated into the system to change the direction of pull so that inspection personnel need not physically enter the pipe, culvert or manhole.

A copy of the Storm Sewer/Culvert Inspection Report (inspection report) including any video tape/Digital Video Recording (DVD)/digital photographs shall be provided to the VDOT Inspector within two business days of the completion of the inspection and made part of the project records. Additionally, a copy shall be furnished to local VDOT Asset Management personnel to document the pipe/culvert condition at that point in time. The video tape/DVD/digital photographs should be of such clarity, detail and resolution as to clearly show the conditions of the interior of the pipe/culvert and detect any defects within the pipe or culvert as specified herein. Post installation inspections shall be conducted no sooner than 30 days after completion of installation and placement of final cover (except for pavement structure).

**PROCEDURES**

The post installation inspection shall be conducted in accordance with the requirements of Section 302.03(d) of the Road and Bridge Specifications and the instructions included herein. The inspection report shall identify the

location of the pipe/culvert being inspected with respect to the project site. The inspection report shall identify the location of the inspection access point of the pipe/culvert being inspected with respect to the plans (e.g., north/south/east/west end of the pipe/culvert, manhole/drop inlet/junction box structure number, etc.). The location of any deficiencies within the pipe/culvert shall be noted in the inspection report by identifying the distance from the inspection access point. If no deficiencies are noted, an "OK" entry shall be made in the report under the remarks column for each section of pipe/culvert inspected.

Where deficiencies are found, a video recording is to be used to identify the deficiency in addition to it being noted on the report form. The video camera system shall be capable of capturing clear images. The camera system shall have a titler/keyboard for data entry and an audio microphone for verbal descriptions; both a textual note on the video/images and a verbal description shall be used to note deficiencies. The camera system shall have a locator system for locating the position of the camera, and a footage counter on the cable reel. The location and description of the deficiency should be added to the recording by the use of an audio microphone. When deficiencies are noted that require remedial actions, the contractor's proposed remediation measures shall be noted in the report form.

The Department shall review the post construction inspection report including any proposed remediation measures and communicate its findings to the Contractor within 10 days of receiving the report. Where the Department agrees with the proposed remediation measures, the contractor shall be notified of such approval and authorized to begin such work. Where the Department disagrees with the proposed remediation measures or where the Department identifies additional deficiencies that require remedial action, the contractor shall be notified of such findings and requested to submit a supplemental remediation plan. Pipes or culverts that required coating should have the coating inspected. Cracks (longitudinal and circumferential) shall be noted in the inspection report and photographed (if not videoed) and digitally scanned to allow for accurate measurement. Spalls and slabbing locations shall be photographed (or videoed) and noted in the report.

Upon completion of the corrective measures, the remedial locations are to be re-inspected prior to final acceptance of the project by the same test methods noted herein. Re-inspection shall be made within 10 days of correction except where sections of pipe/culvert have been replaced re-inspection shall not occur sooner than 30 days after replacement of pipe/culvert and final cover (except for pavement structure).

### **DEFICIENCIES**

Deficiencies may include, but are not limited to, the following:

1. Crushed, collapsed or deformed pipe/culvert or joints.
2. Alignment defects would include sags in the longitudinal profile and invert heaving.
3. Improper joints that can allow leaking of water or infiltration of backfill or surrounding soils.
4. Misaligned joints that can cause debris accumulation.
5. Pipe/culvert that has been penetrated by guardrail or other posts or improper backfill materials or methods.
6. Debris, construction or other materials in the pipe/culvert or structures.
7. Coating material shall be free of cracks, scratches and peeling.

