CHAPTER 6
FIELD DENSITY TESTING

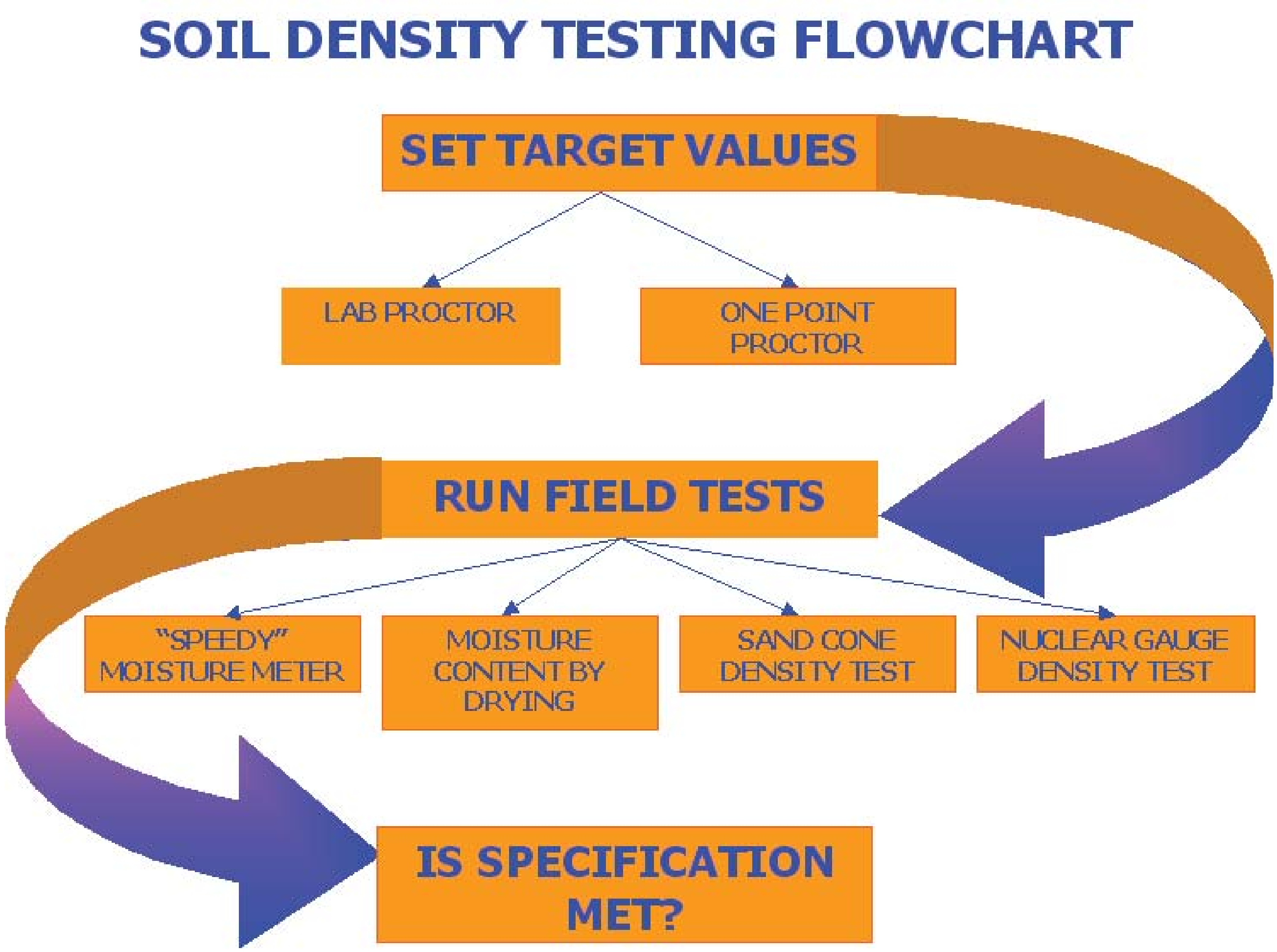
Introduction

After placement and compaction of the embankment material by the contractor, the inspector then conducts a field density test and a field moisture content test on the lift. The results of these field tests are compared to the target values (see Chapter 5) to determine if the contractor has met specifications for density and moisture content of that lift.

Section 303.04(h) and 305.03(a) of 2007 Road and Bridge Specifications stipulates that field density determination are to be performed in accordance with the following AASHTO tests:

T191- Density of Soil in Place by the Sand Cone Method

T324- Density of Soil in Place by the Nuclear Gauge



DENSITY TESTING WITH THE SAND CONE

This section of the Manual will cover compaction testing with the sand cone. This method is used to determine the density in place of a compacted lift of soil.

All calculations and information for the sand cone test will be recorded on the TL 125, which also will serve as a guide to the procedure.

PRETEST CALIBRATIONS

A. First, calibrate the unit weight of the sand. This is typically done in the laboratory. ANY VIBRATION DURING THIS PROCESS WILL RESULT IN SETTLING AND DENSIFICATION OF THE SAND AND LEAD TO AN ERRONEOUS RESULT.

1. Record the empty weight of the proctor mold and base plate. Invert and support the sand cone apparatus over a four inch proctor mold. Open the valve and allow the mold to fill until it just overflows, then close the valve.

2. Strike off the top with a straight edge, being VERY CAREFUL to cause no vibration. Clean the excess sand off of the mold.

3. Weigh the sand and the mold

4. Subtract the weight of the mold to obtain the weight of the sand in the mold.

5. Calculate the unit weight of the sand by multiplying the weight of the sand in the mold by 30.

6. Repeat this three times and average the results. There should be no more than 1% variation. Record this weight on line A of the TL-125.

Note: The sand used in this test must be clean, dry, uniform in density and grading, uncemented, durable, and free flowing. Any gradation may be used that has a uniformity coefficient (Cu = D60/D10) less than 2.0, a maximum particle size smaller than 2.0 mm (No. 10 sieve), and less than 3% by weight passing 250μm (No. 60 sieve).

B. Determine the weight of sand in the cone and base plate.

1. Fill the sand cone apparatus with clean dry sand. Weigh the apparatus and record the weight.

2. Place the base plate on a clean, level surface. Invert the sand cone apparatus and place the cone in the flanged hole in the base plate. Mark the apparatus and base plate so that they can be matched and reseated in the same position during testing.

3. Open the valve fully. When the sand stops running, close the valve.

4. Lift the sand cone apparatus and determine the mass of the apparatus and remaining sand. Subtract this mass from the original mass. This is the weight of the sand that fills the cone and base plate.

5. Repeat this three times and average the results. There should be no more than 1% variation. Record on line D.

TEST PROCEDURE
(This is a summary, refer to ASTM D 1556 for the complete procedure.)

A. Determine the weight of the soil in the hole used for the test.

1. Prepare an area on the compacted lift to run the actual density test. The area will need to be about a foot square and flat. The base plate may be used to strike off the test site to a level plane.

2. Seat the base plate on the leveled test site, making sure the edge of the center hole is in contact with the ground surface. Mark the outline of the base plate to check for movement during the test. The base plate may be secured by pushing nails in the soil adjacent to the edge of the base plate. Weight empty weight of water tight container and record on line I.

3. Dig the test hole through the hole in the base plate. See the note concerning test hole volume. Test hole depth should approximate the thickness of the lift being tested. The sides of the test hole should be straight or taper slightly inward to a flat or conical bottom. Avoid overhangs and pockets in the sides of the test hole.

Note: The minimum volume of the hole is dependent upon maximum particle size of the material to be tested (see table listed below). When the volume exceeds 0.1 cubic feet a larger jar and cone may be needed. For the problems in this chapter assume the maximum particle size is a No. 4. Therefore, a hole that is approximately 4½″ in diameter by 6″ deep will fulfill this requirement.

Table 1.6 Minimum volume of test hole for maximum particle size			
Maximum Particle Size		Minimum Test Hole Volume (ft^3)	Minimum Mass for Moisture Content (g)
mm	US Standard		
4.75	No. 4	0.025	100
12.5	0.5 inch	0.05	250
25	1 inch	0.075	500
50	2 inch	0.1	1000

4. As the soil is dug it should be placed in a water tight container to avoid moisture loss. Make sure that all of the disturbed soil is placed in the container.

5. After the soil is removed, weigh it and record the weight on line H. Protect the sample from moisture loss until a moisture sample can be taken and an oversize correction is determined if needed.

B. Determine the volume of the hole.

The sand will be used to determine the volume of the hole:

1. First fill the jar with sand and weigh the sand-cone apparatus. Record this weight on line B.

2. Invert the sand-cone apparatus over the base plate and hole. Place the bottom of the cone in the flanged hole in the base plate in the same position used during calibration of the apparatus. Eliminate or minimize vibrations in the test area due to personnel or equipment. Turn the valve to the open position.

3. Let the sand run into the hole and when the sand stops running, close the valve.

4. Remove the apparatus with the remaining sand in it and weigh it. Record this on line C, then add this to line D (the weight of the sand in the cone and base plate). Record on line E.

5. The weight of the sand required to fill the test hole is determined by subtracting line E from line B. Record this on line F.

   Wt. of sand, jar & cone – wt. of jar, sand left in jar and sand in cone and base plate = weight of sand in hole

6. The volume of the hole equals the weight of sand required to fill the hole divided by the weight per cubic foot of the sand.

   $$\text{Volume of test hole} = \frac{\text{weight of sand (line F)}}{\text{weight per cubic foot of sand (line A)}}$$

   Record this on line G.

C. Determine the wet unit weight of the soil.

1. Find the weight of the wet soil from the test hole by subtracting the weight of the pan (line I) from the weight of the soil and pan (line H). Record this on line J. When oversize material corrections are required, determine the mass of the oversize material on the appropriate sieve, taking care to avoid moisture loss.

2. Calculate the unit weight per cubic foot of the wet soil by dividing the weight of the wet soil by the volume of the hole and record this on line K.

$$\text{Wet Density (line K)} = \frac{\text{weight of wet soil (line J)}}{\text{volume of hole (line G)}}$$

3. Whether or not the density achieved by the compaction effort passes is based on comparing the dry unit weight of the soil to the maximum dry unit weight of the soil.

D. Determine the dry unit weight of soil

1. Mix the material thoroughly, and either obtain a representative sample for moisture content determination, or use the entire sample. Determine the moisture content by drying over a hotplate or by using the Speedy Moisture Tester. Record on line T.

2. Using this moisture, the dry unit weight per cubic foot of the soil can be determined. Divide the wet weight per cubic foot by 1 plus the moisture content expressed as a decimal:

$$\text{Dry unit weight} = \frac{\text{wet unit weight of soil (K)}}{\{1 + [\text{moisture content (T)} \div 100]\}}$$

This is the dry weight per cubic foot. Enter on line L.

E. Determine the percent compaction by comparing the dry density of the soil in place, to the maximum dry density of the soil.

1. The maximum dry density is determined by the One Point Proctor or the Laboratory Proctor. The Maximum Dry Density and Optimum Moisture Content (regardless of method of determination) are recorded on lines M and N respectively.

2. Divide the Dry Density by the Maximum Dry Density. Multiply by 100 and this is the percent compaction. Enter on line R.

$$\text{Percent Compaction} = \frac{\text{dry density of soil (line L)}}{\text{maximum dry density (line M)}} \times 100$$

F. Determine if the material passes or fails by comparing the percent compaction to the required compaction on line S. The value given on line S is the minimum for that situation. (See Appendix B).

G. Determine if the moisture content of the test sample is within a range of plus or minius 20 percent of the optimum moisture content.

For example, if the optimum moisture content of a soil was 20.3 percent. The moisture content of our test sample must be within a range of 16.2 to 24.4 percent.

To summarize, the percent compaction is determined by finding the density of the soil in place using the sand cone apparatus and comparing this to the maximum dry density that is found by using the laboratory proctor or one point proctor.

SAND CALIBRATION
(Determination of Unit Weight)

WT. OF SAND IN MOLD	2.90	lbs. per mold
	X 30	molds per ft^3
	87.0	lb/ft^3

WT. OF SAND IN MOLD	2.92	lbs.
	X 30	
	87.6	lb/ft^3

WT. OF SAND IN MOLD	2.91	lbs.
	X 30	
	87.3	lb/ft^3

$$\begin{array}{r} 87.0 \\ 87.6 \\ \underline{87.3} \\ 261.9 \end{array}$$

$261.9 \div 3 = 87.3\ lb/ft^3$

87.3 lb/ft^3 - UNIT WEIGHT OF SAND

RECORD ON LINE "A" OF TL-125

TL-125 Rev. 6/00

VIRGINIA DEPARTMENT OF TRANSPORTATION
REPORT OF SAND CONE DENSITY (UNIT MASS OF SOIL)

English ☐ Metric ☐

Report No.: 1 Date: 3-5-99

Route No.: 726 County: Pittsylvania

Project No.: 0726-071-274,C501 FHWA No.: AS-414(101)

Field Test No.		1		
Location of Test	Station ft. (m.)	**27 + 50**		
	Ref. To Center Line ft. (m.)	**1' Rt. C/L**		
Reference Elevation	Original Ground ft. (m.)	**+10'**		
	Finished Grade ft. (m.)	**-26'**		
Compacted Depth of Lift in. (mm.)		**6"**		
Method of Compaction (Type of Roller)		**Sheepsfoot**		
DENSITY DETERMINATION				
A. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of sand (calibrated value)		**87.3**		
B. Wt. (mass) sand + wt. (mass) of jar and cone, lb. (kg)				
C. Wt. (mass) sand left in jar + wt. (mass) of jar and cone, lb. (kg)				
D. Wt. (mass) of sand in cone and base plate, lb. (kg) (calibrated value)				
E. Wt. (mass) sand left in jar + wt. (mass) of jar and cone + wt. (mass) of sand in cone and base plate (C + D), lb.(kg)				
F. Wt. (mass) of sand in test hole (B - E), lb. (kg)				
G. Volume of test hole (F ÷ A), ft^3 (m^3)				
H. Wt. (mass) of wet soil from test hole + (wt.) mass of pan, lb. (kg)				
I. Wt. (mass) of pan, lb. (kg)				
J. Wt. (mass) of wet soil from test hole (H - I), lb. (kg)				
K. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of wet soil in fill (J ÷ G)				
L. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of dry soil in fill = $\frac{K}{\{ 1 + [\text{Moisture Content (T)} \div 100] \}}$				
M. Max. Dry Unit Wt.(lbs/ft^3) or Unit mass (kg/m^3) from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)		**112.0**		
N. Optimum Moisture Content from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)		**15.2**		
O. Percent of +No. 4 (plus 4.75 mm) Material				
P. Corrected Maximum Dry Unit wt. (lbs/ft^3) or Unit mass (kg/m^3)				
Q. Corrected Optimum Moisture (%)				
R. % Compaction (L ÷ M) × 100 or (L ÷ P) × 100				
S. % Minimum density (unit mass) required (from specifications)				
MOISTURE DETERMINATION (For Field Dried Method)				
a. Dish and damp soil, lb. (kg)				
b. Dish and dried soil, lb. (kg)				
c. Wt. (mass) moisture (a - b), lb. (kg)				
d. Wt. (mass) dish, lb. (kg)				
e. Wt. (mass) dry soil (b - d), lb. (kg)				
T. Moisture Content (c ÷ e) × 100 or from "Speedy" Moisture Test				

From Proctor Worksheet (TL-125A) Lines G and H

Remarks: ______ By: ______

______ Title: ______

CALIBRATION OF SAND IN CONE AND BASE PLATE

WT. OF APPARATUS AND SAND	13.32 lb.
WT. OF APPARATUS AND REMAINING SAND	- 10.59 lb.
WT. OF SAND IN CONE AND BASE PLATE	2.73 lb.

WT. OF APPARATUS AND SAND	13.32 lb.
WT. OF APPRATUS AND REMAINING SAND	- 10.61 lb.
WT. OF SAND IN CONE AND BASE PLATE	2.71 lb.

WT. OF APPARATUS AND SAND	13.32 lb.
WT. OF APPARATUS AND REMAINING SAND	- 10.60 lb.
WT. OF SAND IN CONE AND BASE PLATE	2.72 lb.

2.73 lb.
2.71 lb.
2.72 lb.
8.16 lb.

8.16 ÷ 3 = 2.72 lb.

2.72 lb. - WEIGHT OF SAND IN CONE AND BASE PLATE

RECORD ON LINE D ON TL-125

TL-125 Rev. 6/00

VIRGINIA DEPARTMENT OF TRANSPORTATION
REPORT OF SAND CONE DENSITY (UNIT MASS OF SOIL)

English ☐ Metric ☐

Report No.: 1 Date: 3-5-99

Route No.: 726 County: Pittsylvania

Project No.: 0726-071-274,C501 FHWA No.: AS-414(101)

Field Test No.		1		
Location of Test	Station ft. (m.)	**27 + 50**		
	Ref. To Center Line ft. (m.)	**1' Rt. C/L**		
Reference Elevation	Original Ground ft. (m.)	**+10'**		
	Finished Grade ft. (m.)	**-26'**		
Compacted Depth of Lift in. (mm.)		**6"**		
Method of Compaction (Type of Roller)		**Sheepsfoot**		
DENSITY DETERMINATION				
A. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of sand (calibrated value)		**87.3**		
B. Wt. (mass) sand + wt. (mass) of jar and cone, lb. (kg)				
C. Wt. (mass) sand left in jar + wt. (mass) of jar and cone, lb. (kg)				
D. Wt. (mass) of sand in cone and base plate, lb. (kg) (calibrated value)		**2.72**		
E. Wt. (mass) sand left in jar + wt. (mass) of jar and cone + wt. (mass) of sand in cone and base plate (C + D), lb.(kg)				
F. Wt. (mass) of sand in test hole (B - E), lb. (kg)				
G. Volume of test hole (F ÷ A), ft^3 (m^3)				
H. Wt. (mass) of wet soil from test hole + (wt.) mass of pan, lb. (kg)				
I. Wt. (mass) of pan, lb. (kg)				
J. Wt. (mass) of wet soil from test hole (H - I), lb. (kg)				
K. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of wet soil in fill (J ÷ G)				
L. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of dry soil in fill = $\frac{K}{\{1 + [\text{Moisture Content (T)} \div 100]\}}$				
M. Max. Dry Unit Wt.(lbs/ft^3) or Unit mass (kg/m^3) from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)		**112.0**		
N. Optimum Moisture Content from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)		**15.2**		
O. Percent of +No. 4 (plus 4.75 mm) Material				
P. Corrected Maximum Dry Unit wt. (lbs/ft^3) or Unit mass (kg/m^3)				
Q. Corrected Optimum Moisture (%)				
R. % Compaction (L ÷ M) × 100 or (L ÷ P) × 100				
S. % Minimum density (unit mass) required (from specifications)				
MOISTURE DETERMINATION (For Field Dried Method)				
a. Dish and damp soil, lb. (kg)				
b. Dish and dried soil, lb. (kg)				
c. Wt. (mass) moisture (a - b), lb. (kg)				
d. Wt. (mass) dish, lb. (kg)				
e. Wt. (mass) dry soil (b - d), lb. (kg)				
T. Moisture Content (c ÷ e) × 100 or from "Speedy" Moisture Test				

Remarks: ______________________ By: ______________________

______________________ Title: ______________________

____

VIRGINIA DEPARTMENT OF TRANSPORTATION
REPORT OF SAND CONE DENSITY (UNIT MASS OF SOIL)

English ☐ Metric ☐

Report No.: 1 Date: 3-5-99

Route No.: 726 County: Pittsylvania

Project No.: 0726-071-274,C501 FHWA No.: AS-414(101)

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Location of Test — Station ft. (m.)	**27 + 50**		
Location of Test — Ref. To Center Line ft. (m.)	**1' Rt. C/L**		
Reference Elevation — Original Ground ft. (m.)	**+10'**		
Reference Elevation — Finished Grade ft. (m.)	**-26'**		
Compacted Depth of Lift in. (mm.)	**6"**		
Method of Compaction (Type of Roller)	**Sheepsfoot**		
DENSITY DETERMINATION			
A. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of sand (calibrated value)	**87.3**		
B. Wt. (mass) sand + wt. (mass) of jar and cone, lb. (kg)			
C. Wt. (mass) sand left in jar + wt. (mass) of jar and cone, lb. (kg)			
D. Wt. (mass) of sand in cone and base plate, lb. (kg) (calibrated value)	**2.72**		
E. Wt. (mass) sand left in jar + wt. (mass) of jar and cone + wt. (mass) of sand in cone and base plate (C + D), lb.(kg)			
F. Wt. (mass) of sand in test hole (B - E), lb. (kg)			
G. Volume of test hole (F ÷ A), ft^3 (m^3)			
H. Wt. (mass) of wet soil from test hole + (wt.) mass of pan, lb. (kg)	**9.60**		
I. Wt. (mass) of pan, lb. (kg)	**1.72**		
J. Wt. (mass) of wet soil from test hole (H - I), lb. (kg)	**7.88**		
K. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of wet soil in fill (J ÷ G)			
L. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of dry soil in fill = $\frac{K}{\{1 + [\text{Moisture Content (T)} \div 100]\}}$			
M. Max. Dry Unit Wt.(lbs/ft^3) or Unit mass (kg/m^3) from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)	**112.0**		
N. Optimum Moisture Content from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)	**15.2**		
O. Percent of +No. 4 (plus 4.75 mm) Material			
P. Corrected Maximum Dry Unit wt. (lbs/ft^3) or Unit mass (kg/m^3)			
Q. Corrected Optimum Moisture (%)			
R. % Compaction (L ÷ M) × 100 or (L ÷ P) × 100			
S. % Minimum density (unit mass) required (from specifications)			
MOISTURE DETERMINATION (For Field Dried Method)			
a. Dish and damp soil, lb. (kg)			
b. Dish and dried soil, lb. (kg)			
c. Wt. (mass) moisture (a - b), lb. (kg)			
d. Wt. (mass) dish, lb. (kg)			
e. Wt. (mass) dry soil (b - d), lb. (kg)			
T. Moisture Content (c ÷ e) × 100 or from "Speedy" Moisture Test			

9.60 lb.
- 1.72 lb.
7.88 lb.

Remarks: ______ By: ______

Title: ______

TL-125 Rev. 6/00

VIRGINIA DEPARTMENT OF TRANSPORTATION
REPORT OF SAND CONE DENSITY (UNIT MASS OF SOIL)

English ☐ Metric ☐

Report No.: 1 Date: 3-5-99

Route No.: 726 County: Pittsylvania

Project No.: 0726-071-274,C501 FHWA No.: AS-414(101)

Field Test No.	1		
Location of Test — Station ft. (m.)	27 + 50		
Location of Test — Ref. To Center Line ft. (m.)	**1' Rt. C/L**		
Reference Elevation — Original Ground ft. (m.)	**+10'**		
Reference Elevation — Finished Grade ft. (m.)	**-26'**		
Compacted Depth of Lift in. (mm.)	**6"**		
Method of Compaction (Type of Roller)	**Sheepsfoot**		
DENSITY DETERMINATION			
A. Unit wt.(lbs/ft³) or Unit mass (kg/m³) of sand (calibrated value)	**87.3**		
B. Wt. (mass) sand + wt. (mass) of jar and cone, lb. (kg)	**13.32**		
C. Wt. (mass) sand left in jar + wt. (mass) of jar and cone, lb. (kg)	**5.12**		
D. Wt. (mass) of sand in cone and base plate, lb. (kg) (calibrated value)	**2.72**		
E. Wt. (mass) sand left in jar + wt. (mass) of jar and cone + wt. (mass) of sand in cone and base plate (C + D), lb.(kg)	**7.84**		
F. Wt. (mass) of sand in test hole (B - E), lb. (kg)			
G. Volume of test hole (F ÷ A), ft³ (m³)			
H. Wt. (mass) of wet soil from test hole + (wt.) mass of pan, lb. (kg)	**9.60**		
I. Wt. (mass) of pan, lb. (kg)	**1.72**		
J. Wt. (mass) of wet soil from test hole (H - I), lb. (kg)	**7.88**		
K. Unit wt.(lbs/ft³) or Unit mass (kg/m³) of wet soil in fill (J ÷ G)			
L. Unit wt.(lbs/ft³) or Unit mass (kg/m³) of dry soil in fill = $\frac{K}{\{1 + [\text{Moisture Content (T)} \div 100]\}}$			
M. Max. Dry Unit Wt.(lbs/ft³) or Unit mass (kg/m³) from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)	**112.0**		
N. Optimum Moisture Content from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)	**15.2**		
O. Percent of +No. 4 (plus 4.75 mm) Material			
P. Corrected Maximum Dry Unit wt. (lbs/ft³) or Unit mass (kg/m³)			
Q. Corrected Optimum Moisture (%)			
R. % Compaction (L ÷ M) × 100 or (L ÷ P) × 100			
S. % Minimum density (unit mass) required (from specifications)			
MOISTURE DETERMINATION (For Field Dried Method)			
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b. Dish and dried soil, lb. (kg)			
c. Wt. (mass) moisture (a - b), lb. (kg)			
d. Wt. (mass) dish, lb. (kg)			
e. Wt. (mass) dry soil (b - d), lb. (kg)			
T. Moisture Content (c ÷ e) × 100 or from "Speedy" Moisture Test			

5.12 lb.
+ 2.72 lb.
7.84 lb.

Remarks: By:

Title:

TL-125 Rev. 6/00

VIRGINIA DEPARTMENT OF TRANSPORTATION
REPORT OF SAND CONE DENSITY (UNIT MASS OF SOIL)

English ☐ Metric ☐

Report No.: 1 Date: 3-5-99

Route No.: 726 County: Pittsylvania

Project No.: 0726-071-274,C501 FHWA No.: AS-414(101)

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D. Wt. (mass) of sand in cone and base plate, lb. (kg) (calibrated value)	**2.72**		
E. Wt. (mass) sand left in jar + wt. (mass) of jar and cone + wt. (mass) of sand in cone and base plate (C + D), lb.(kg)	**7.84**		
F. Wt. (mass) of sand in test hole (B - E), lb. (kg)	**5.48**		
G. Volume of test hole (F ÷ A), ft^3 (m^3)	**0.0628**		
H. Wt. (mass) of wet soil from test hole + (wt.) mass of pan, lb. (kg)	**9.60**		
I. Wt. (mass) of pan, lb. (kg)	**1.72**		
J. Wt. (mass) of wet soil from test hole (H - I), lb. (kg)	**7.88**		
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c. Wt. (mass) moisture (a - b), lb. (kg)			
d. Wt. (mass) dish, lb. (kg)			
e. Wt. (mass) dry soil (b - d), lb. (kg)			
T. Moisture Content (c ÷ e) × 100 or from "Speedy" Moisture Test			

13.32 lb.
- 7.84 lb.
5.48 lb.

$$\frac{5.48 \text{ lb.}}{87.3 \text{ lb/ft}^3} = 0.0628 \text{ ft}^3$$

Remarks: ______________________ By: ______________________

______________________ Title: ______________________

____

TL-125 Rev. 6/00

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English ☐ Metric ☐

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Location of Test	Station ft. (m.)	**27 + 50**	
	Ref. To Center Line ft. (m.)	**1' Rt. C/L**	
Reference Elevation	Original Ground ft. (m.)	**+10'**	
	Finished Grade ft. (m.)	**-26'**	
Compacted Depth of Lift in. (mm.)		**6"**	
Method of Compaction (Type of Roller)		**Sheepsfoot**	
DENSITY DETERMINATION			
A. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of sand (calibrated value)		**87.3**	
B. Wt. (mass) sand + wt. (mass) of jar and cone, lb. (kg)		**13.32**	
C. Wt. (mass) sand left in jar + wt. (mass) of jar and cone, lb. (kg)		**5.12**	
D. Wt. (mass) of sand in cone and base plate, lb. (kg) (calibrated value)		**2.72**	
E. Wt. (mass) sand left in jar + wt. (mass) of jar and cone + wt. (mass) of sand in cone and base plate (C + D), lb.(kg)		**7.84**	
F. Wt. (mass) of sand in test hole (B - E), lb. (kg)		**5.48**	
G. Volume of test hole (F ÷ A), ft^3 (m^3)		**0.0628**	
H. Wt. (mass) of wet soil from test hole + (wt.) mass of pan, lb. (kg)		**9.60**	
I. Wt. (mass) of pan, lb. (kg)		**1.72**	
J. Wt. (mass) of wet soil from test hole (H - I), lb. (kg)		**7.88**	
K. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of wet soil in fill (J ÷ G)		**125.5**	
L. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of dry soil in fill = $\frac{K}{\{1 + [\text{Moisture Content (T)} \div 100]\}}$			
M. Max. Dry Unit Wt.(lbs/ft^3) or Unit mass (kg/m^3) from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)			
N. Optimum Moisture Content from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)		**15.2**	
O. Percent of +No. 4 (plus 4.75 mm) Material			
P. Corrected Maximum Dry Unit wt. (lbs/ft^3) or Unit mass (kg/m^3)			
Q. Corrected Optimum Moisture (%)			
R. % Compaction (L ÷ M) × 100 or (L ÷ P) × 100			
S. % Minimum density (unit mass) required (from specifications)			
MOISTURE DETERMINATION (For Field Dried Method)			
a. Dish and damp soil, lb. (kg)			
b. Dish and dried soil, lb. (kg)			
c. Wt. (mass) moisture (a - b), lb. (kg)			
d. Wt. (mass) dish, lb. (kg)			
e. Wt. (mass) dry soil (b - d), lb. (kg)			
T. Moisture Content (c ÷ e) × 100 or from "Speedy" Moisture Test			

$$\frac{7.88\ \text{lb.}}{0.0628\ \text{ft}^3} = 125.5\ \text{lb/ft}^3$$

Remarks: ______ By: ______

Title: ______

SPEEDY READ.	MOIST. CONT.	SPEEDY READ.	MOIST. CONT.	SPEEDY READ.	MOIST. CONT.	SPEEDY READ.	MOIST. CONT.	SPEEDY READ.	MOIST. CONT.	SPEEDY READ.	MOIST. CONT.
1.0	1.0	8.2	9.0	15.2	18.0	22.4	28.9	29.6	42.1	36.8	58.3
1.2	1.3	8.4	9.2	15.4	18.3	22.6	29.2	29.8	42.5	37.0	58.8
1.4	1.5	8.6	9.5	15.6	18.5	22.8	29.6	30.0	42.9	37.2	59.3
1.6	1.8	8.8	9.7	15.8	18.8	23.0	30.2	30.2	43.3	37.4	59.8
1.8	2.0	9.0	9.9	16.0	19.1	23.2	30.6	30.4	43.8	37.6	60.3
2.0	2.2	9.2	10.1	16.2	19.4	23.4	30.9	30.6	44.2	37.8	60.8
2.2	2.4	9.4	10.4	16.4	19.6	23.6	31.3	30.8	44.6	38.0	61.3
2.4	2.6	9.6	10.6	16.6	19.9	23.8	31.6	31.0	45.0	38.2	61.8
2.6	2.9	9.8	10.8	16.8	20.2	24.0	31.9	31.2	45.4	38.4	62.4
2.8	3.1	10.0	11.1	17.0	20.5	24.2	32.3	31.4	45.8	38.6	62.9
3.0	3.3	10.2	11.4	17.2	20.8	24.4	32.7	31.6	46.2	38.8	63.5
3.2	3.5	10.4	11.6	17.4	21.1	24.6	33.0	31.8	46.6	39.0	64.0
3.4	3.7	10.6	11.9	17.6	21.4	24.8	33.4	32.0	47.1	39.2	64.5
3.6	4.0	10.8	12.1	17.8	21.7	25.0	33.7	32.2	47.5	39.4	65.0
3.8	4.2	11.0	12.4	18.0	22.0	25.2	34.1	32.4	48.0	39.6	65.6
4.0	4.4	11.2	12.7	18.2	22.3	25.4	34.5	32.6	48.4	39.8	66.1
4.2	4.6	11.4	12.9	18.4	22.6	25.6	34.9	32.8	48.8	40.0	66.7
4.4	4.8	11.6	13.2	18.6	23.0	25.8	35.4	33.0	49.3	40.2	67.2
4.6	5.1	11.8	13.4	18.8	23.2	26.0	35.7	33.2	49.7	40.4	67.8
4.8	5.3	12.0	13.7	19.0	23.5	26.2	35.9	33.4	50.2	40.6	68.4
5.0	5.5	12.2	13.9	19.2	23.8	26.4	36.3	33.6	50.6	40.8	68.9
5.2	5.7	12.4	14.2	19.4	24.1	26.6	36.6	33.8	51.1	41.0	69.5
5.4	5.9	12.6	14.4	19.6	24.4	26.8	37.0	34.0	51.6	41.2	70.1
5.6	6.2	12.8	14.7	19.8	24.8	27.0	37.4	34.2	52.0	41.4	70.7
5.8	6.4	13.0	15.0	20.0	25.1	27.2	37.8	34.4	52.5	41.6	71.3
6.0	6.6	13.2	15.3	20.2	25.4	27.4	38.2	34.6	52.9	41.8	71.9
6.2	6.8	13.4	15.5	20.4	25.7	27.6	38.5	34.8	53.4	42.0	72.5
6.4	7.0	13.6	15.8	20.6	26.0	27.8	38.9	35.0	53.9	42.2	73.0
6.6	7.3	13.8	16.1	20.8	26.3	28.0	39.3	35.2	54.4	42.4	73.6
6.8	7.5	14.0	16.4	21.0	26.6	28.2	39.7	35.4	54.8	42.6	74.2
7.0	7.7	14.2	16.6	21.2	26.9	28.4	40.1	35.6	55.3	42.8	74.8
7.2	7.9	**14.4**	**16.9**	21.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	75.5
7.4	8.1	14.6	17.1	21.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	76.1
7.6	8.4	14.8	17.4	21.8	28.0	29.0	41.3	36.2	56.8	43.4	76.7
7.8	8.6	15.0	17.7	22.0	28.3	29.2	41.5	36.4	57.2	43.6	77.3
8.0	8.8	15.2	18.0	22.2	28.6	29.4	41.7	36.6	57.5	43.8	78.0

Speedy Reading for Sand Cone

TL-125 Rev. 6/00

VIRGINIA DEPARTMENT OF TRANSPORTATION
REPORT OF SAND CONE DENSITY (UNIT MASS OF SOIL)

English ☐ Metric ☐

Report No.: 1 Date: 3-5-99

Route No.: 726 County: Pittsylvania

Project No.: 0726-071-274,C501 FHWA No.: AS-414(101)

Field Test No.		1		
Location of Test	Station ft. (m.)	27 + 50		
	Ref. To Center Line ft. (m.)	1' Rt. C/L		
Reference Elevation	Original Ground ft. (m.)	+10'		
	Finished Grade ft. (m.)	-26'		
Compacted Depth of Lift in. (mm.)		6"		
Method of Compaction (Type of Roller)		Sheepsfoot		
DENSITY DETERMINATION				
A. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of sand (calibrated value)		87.3		
B. Wt. (mass) sand + wt. (mass) of jar and cone, lb. (kg)		13.32		
C. Wt. (mass) sand left in jar + wt. (mass) of jar and cone, lb. (kg)		5.12		
D. Wt. (mass) of sand in cone and base plate, lb. (kg) (calibrated value)		2.72		
E. Wt. (mass) sand left in jar + wt. (mass) of jar and cone + wt. (mass) of sand in cone and base plate (C + D), lb.(kg)		7.84		
F. Wt. (mass) of sand in test hole (B - E), lb. (kg)		5.48		
G. Volume of test hole (F ÷ A), ft^3 (m^3)		0.0628		
H. Wt. (mass) of wet soil from test hole + (wt.) mass of pan, lb. (kg)		9.60		
I. Wt. (mass) of pan, lb. (kg)		1.72		
J. Wt. (mass) of wet soil from test hole (H - I), lb. (kg)		7.88		
K. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of wet soil in fill (J ÷ G)		125.5		
L. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of dry soil in fill = $\frac{K}{\{1 + [\text{Moisture Content (T)} \div 100]\}}$		107.4		
M. Max. Dry Unit Wt.(lbs/ft^3) or Unit mass (kg/m^3) from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)				
N. Optimum Moisture Content from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)				
O. Percent of +No. 4 (plus 4.75 mm) Material				
P. Corrected Maximum Dry Unit wt. (lbs/ft^3) or Unit mass (kg/m^3)				
Q. Corrected Optimum Moisture (%)				
R. % Compaction (L ÷ M) × 100 or (L ÷ P) × 100				
S. % Minimum density (unit mass) required (from specifications)				
MOISTURE DETERMINATION (For Field Dried Method)				
a. Dish and damp soil, lb. (kg)				
b. Dish and dried soil, lb. (kg)				
c. Wt. (mass) moisture (a - b), lb. (kg)				
d. Wt. (mass) dish, lb. (kg)				
e. Wt. (mass) dry soil (b - d), lb. (kg)				
T. Moisture Content (c ÷ e) × 100 or from "Speedy" Moisture Test		16.9		

$$L = \frac{K}{1+\{\text{Moisture Content (T)} \div 100\}}$$

$$L = \frac{125.5}{1 + \frac{16.9}{100}}\ lb/ft^3$$

$$L = \frac{125.5}{1 + 0.169}\ lb/ft^3$$

$$L = \frac{125.5}{1.169}\ lb/ft^3$$

$$L = 107.4\ lb/ft^3$$

Remarks: ____________________ By: ____________________

____________________ Title: ____________________

TL-125 Rev. 6/00

VIRGINIA DEPARTMENT OF TRANSPORTATION
REPORT OF SAND CONE DENSITY (UNIT MASS OF SOIL)

English ☐ Metric ☐

Report No.: 1 Date: 3-5-99

Route No.: 726 County: Pittsylvania

Project No.: 0726-071-274,C501 FHWA No.: AS-414(101)

Field Test No.		1		
Location of Test	Station ft. (m.)	**27 + 50**		
	Ref. To Center Line ft. (m.)	**1' Rt. C/L**		
Reference Elevation	Original Ground ft. (m.)	**+10'**		
	Finished Grade ft. (m.)	**-26'**		
Compacted Depth of Lift in. (mm.)		**6"**		
Method of Compaction (Type of Roller)		**Sheepsfoot**		
DENSITY DETERMINATION				
A. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of sand (calibrated value)		**87.3**		
B. Wt. (mass) sand + wt. (mass) of jar and cone, lb. (kg)		**13.32**		
C. Wt. (mass) sand left in jar + wt. (mass) of jar and cone, lb. (kg)		**5.12**		
D. Wt. (mass) of sand in cone and base plate, lb. (kg) (calibrated value)		**2.72**		
E. Wt. (mass) sand left in jar + wt. (mass) of jar and cone + wt. (mass) of sand in cone and base plate (C + D), lb.(kg)		**7.84**		
F. Wt. (mass) of sand in test hole (B - E), lb. (kg)		**5.48**		
G. Volume of test hole (F ÷ A), ft^3 (m^3)		**0.0628**		
H. Wt. (mass) of wet soil from test hole + (wt.) mass of pan, lb. (kg)		**9.60**		
I. Wt. (mass) of pan, lb. (kg)		**1.72**		
J. Wt. (mass) of wet soil from test hole (H - I), lb. (kg)		**7.88**		
K. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of wet soil in fill (J ÷ G)		**125.5**		
L. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of dry soil in fill = $\frac{K}{\{1 + [\text{Moisture Content (T)} \div 100]\}}$		**107.4**		
M. Max. Dry Unit Wt.(lbs/ft^3) or Unit mass (kg/m^3) from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)		**112.0**		
N. Optimum Moisture Content from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)		**15.2**		
O. Percent of +No. 4 (plus 4.75 mm) Material				
P. Corrected Maximum Dry Unit wt. (lbs/ft^3) or Unit mass (kg/m^3)				
Q. Corrected Optimum Moisture (%)				
R. % Compaction (L ÷ M) × 100 or (L ÷ P) × 100		**95.9**		
S. % Minimum density (unit mass) required (from specifications)		**95.0**		
MOISTURE DETERMINATION (For Field Dried Method)				
a. Dish and damp soil, lb. (kg)				
b. Dish and dried soil, lb. (kg)				
c. Wt. (mass) moisture (a - b), lb. (kg)				
d. Wt. (mass) dish, lb. (kg)				
e. Wt. (mass) dry soil (b - d), lb. (kg)				
T. Moisture Content (c ÷ e) × 100 or from "Speedy" Moisture Test		**16.9**		

$$\frac{107.4 \ lb/ft^3}{112.0 \ lb/ft^3} = 0.9589$$

$$0.9589 \times 100 = 95.9$$

Remarks: ______________________ By: ______________________

______________________ Title: ______________________

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TL-125A (Rev. 7/00)

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
WORKSHEET FOR ONE-POINT PROCTOR

Route No. : 726 County : Pittsylvania
Project No. : 0726-071-274,C501 Inspected by :
F.H.W.A. No. : AS-414(101)

English ☐ Metric ☐

Field Test No.		1			
Date		3-5-99			
Location of test	Station ft. (m)	27 + 50			
	Ref. to center line ft. (m)	3' Rt. C/L			
Reference Elevation	Original ground ft. (m)	+10'			
	Finished grade ft. (m)	-26'			
Type of roller		Sheepsfoot			

A. Weight (mass) of mold and wet soil. lb. (kg.) =	13.57			
B. Weight (mass) of mold lb. (kg) =	9.34			
C. Weight (mass) of wet soil. A - B lb. (kg) =	4.23			
D. Wet density of soil. C x 30 lb/ft³ (C x 1060 kg/m³) =	126.9			
E. "Speedy " Dial Reading =	11.6			
F. Moisture Content, %, from "Speedy" chart. =	13.2			
G. Maximum Dry Density lb/ft³ (kg/m³) =	112.0			
H. Optimum Moisture Content, % =	15.2			
I. Field Density lb/ft³ (kg/m³) from TL-125 =	107.4 ← From TL-125 Line L			
J. No. 4 (+4.75 mm) material from field density hole. =				
K. Corrected Maximum Density lb/ft³ (kg/m³) =				
L. % Compaction =	95.9 ← From TL-125 Line R			

Remarks:

CC: District Materials Engineer
Project File

By: D. Sayre

Title: Engr. Tech. VI

Report No.: 1-A

Determination of Passing/Failing Results

The results of the sand cone test must meet density and moisture requirements to be considered a passing test.

To determine if the test passes on density, look at the Reference Elevation to determine if the test was taken in the embankment or subgrade area.

This test was taken 26 feet below finished grade, which is in the embankment. Appendices C states "For soil embankments, the minimum allowable density is 95 percent of the theoretical maximum density."

95.9% compaction was achieved (Line R), so the test passes on density.

Now look at the moisture results.

The specifications require that each lift be compacted at optimum moisture content (OMC) tolerance of ± 20% of that moisture content.

15.2% is the optimum moisture content (Line N).

20% of OMC = 15.2% x 0.20 = 3.04%

-20% of OMC = 15.2% – 3.04% = 12.16% = 12.2%

+20% of OMC = 15.2% + 3.04% = 18.24% = 18.2%

Optimum Moisture Range = 12.2% to 18.2%

16.9% Moisture Content (Line T) falls within the 12.2% to 18.2% range so the test passes on moisture as well as density.

FIELD DENSITY & MOISTURE CONTENT WITH THE NUCLEAR TESTING GAUGE

The Nuclear Moisture Density device is specifically designed to measure the moisture and density of soils, aggregates, cement, and lime treated materials, and to measure the density of asphalt concrete. It offers the Inspector and Contractor a method of obtaining fast, accurate and in-place measurement of densities and moisture. With suitable calibrations, the device gives results which are comparable to those given by the Sand Cone or Volume Meter Test.

The device uses a small radioactive source which sends radiation through the material being tested, giving data which can be correlated to density and/or moisture. While no radiation hazard is imposed on the operator when following the normal procedures of use, a potential hazard does exist if improperly used. Three ways to limit exposure to radiation are time, distance, and shielding.

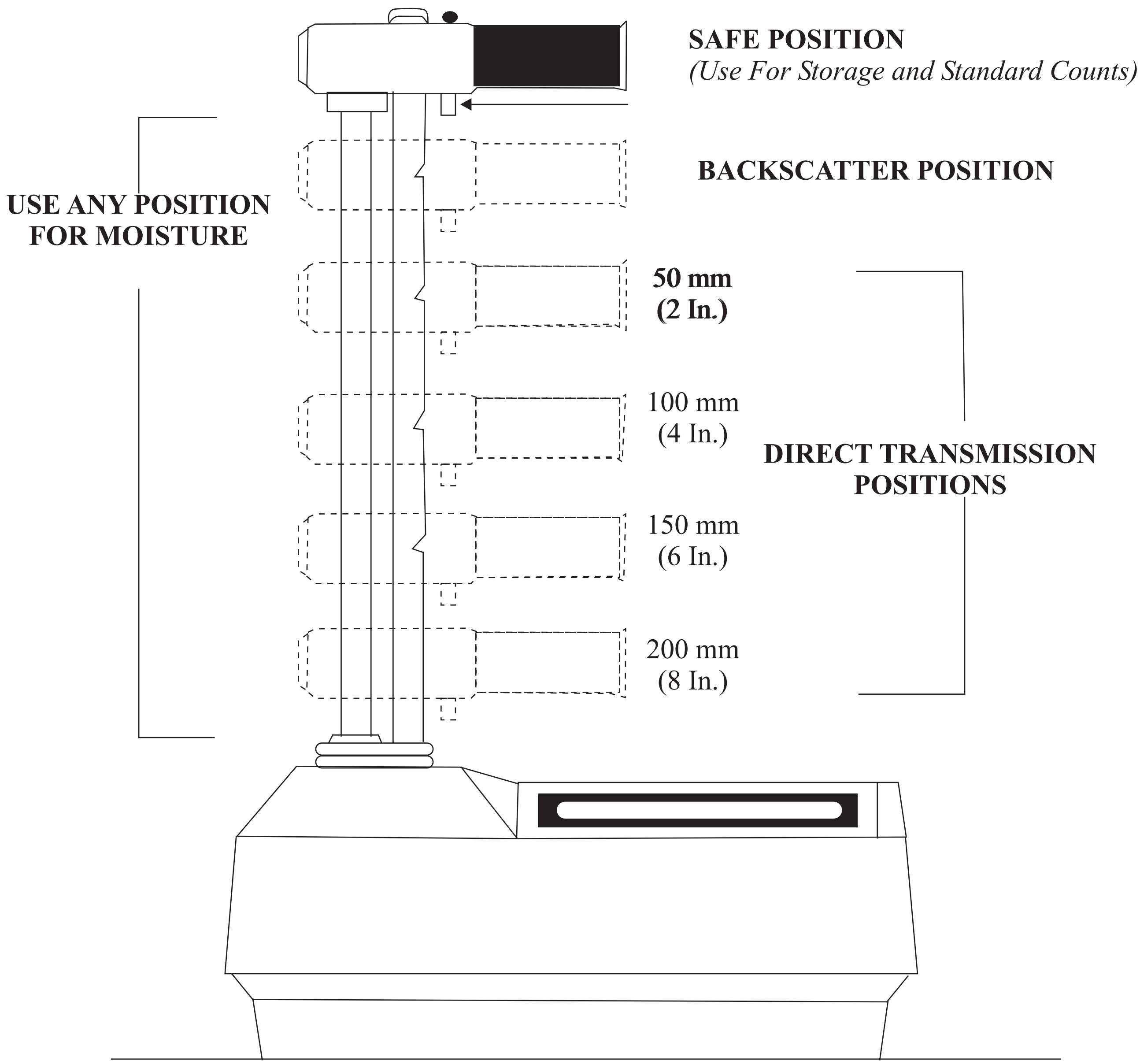
Before operating a nuclear gauge a person must pass a Nuclear Safety course and be issued a TLD (Thermoluminescent dosimeter) badge. The badge measures exposure to radiation and is to be worn whenever operating a nuclear gauge. The TLD is to be stored at least 10 feet from the gauge. Two gauges should not be operated within 33 feet of one another. In case of an accident, maintain a 20 foot radius around the accident site.

COMPONENTS OF THE NUCLEAR GAUGE

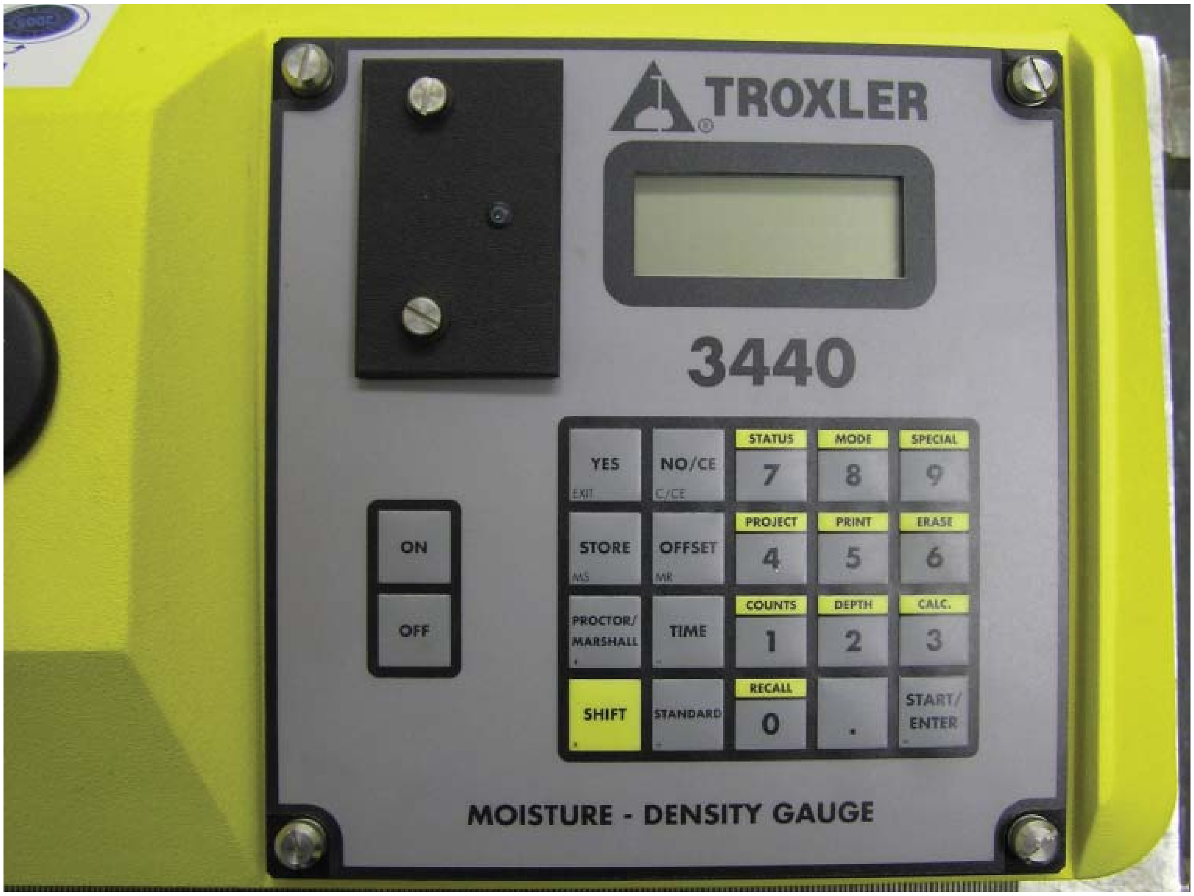
A small radioactive source is located in the tip of the stainless steel rod which is primarily used for density testing, whereas another source is located inside the device which is used specifically for taking moisture determinations simultaneously. The probe rod is capable of being moved to the various desired depths, as shown on the following pages. The positions are stamped on the guide rod for easy determination of the proper depths.

The 3440 gauge provides three different count times to be used for taking readings. The 15 second setting is recommended to be used only in the roller pattern test method (Backscatter method). The one minute setting is used for all embankment and subgrade materials. The four minute setting is generally used for calibration.

3440 Handle Positions



3440 Display Screen



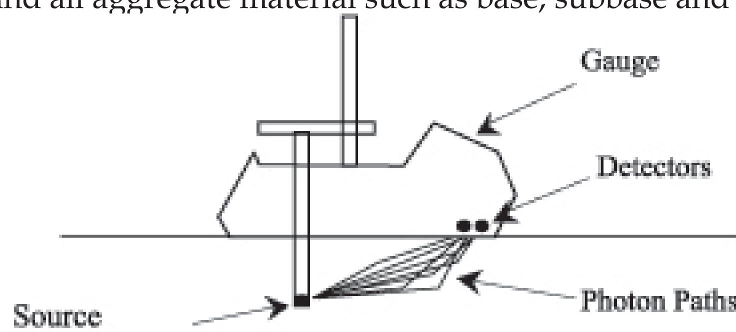
THEORY OF OPERATIONS

The nuclear moisture density gauge is specifically designed to measure the moisture content and density of soils, aggregates, cement and lime treated materials, and to measure the density of Bituminous Concrete. It offers the inspector a method of obtaining fast, accurate, in-place measurement of density and moisture. With suitable laboratory calibrations, and proper field operation of the gauge, the device gives results which are comparable to those given by the sand cone or volume meter tests.

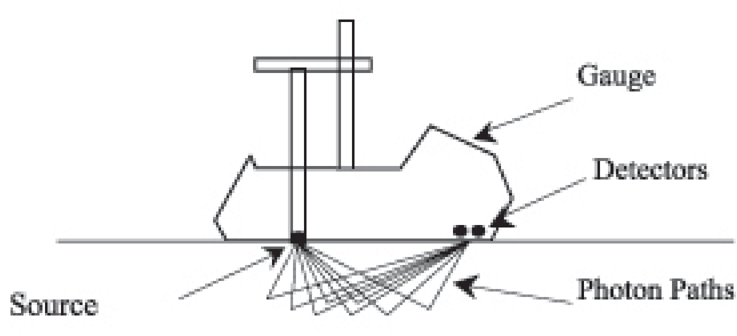
The tip of the source rod contains a small radioactive source (cesium-137) which emits gamma rays. Detectors in the base of the gauge measure this radiation and calculate the density of the material. The gauge has two modes to measure density: the direct transmission mode and backscatter mode.

In the direct transmission mode, the source rod is inserted into the material to be tested to the desired depth of test. The 6 inch depth is the most recommended depth for testing densities and moisture content simultaneously in soils used in backfills, embankments and subgrade. The 4 inch depth is used for backfilling around pipe and abutments where hand tamping and pneumatic tamping is used. The 8 inch depth is only used when specified on the contract.

In the backscatter mode the gauge is placed on the material to be tested and the source rod is locked in the first position below the SAFE position. Since the rod is flush with the bottom of the gauge and no hole is required for the rod, the backscatter mode is used only in conjunction with the roller pattern/control strip method for testing densities on asphalt concrete and all aggregate material such as base, subbase and select materials.



Direct Transmission Method



Backscatter Method

The gauge has an internal radioactive source (Americium-241:Beryllium) that emits neutrons which measure the hydrogen to determine moisture content. Any position below the SAFE position can be used to determine moisture content.

Problems may arise when testing materials containing mica, boron, cadmium and chlorine or when testing heavy clays and organic material. It is permissible to use the Speedy Moisture Tester to verify nuclear results.

Like the conventional test, the operator must compare the results from the nuclear gauge to the one point proctor or laboratory proctor. The nuclear density is compared to the maximum dry density to calculate the percent density and the moisture content from the nuclear gauge is compared to the optimum moisture limits.

PRETEST WARM-UP PROCEDURES
FOR THE 3440 GAUGE

The standard count should be taken daily before any testing is done to check gauge operation and allow the gauge to compensate for natural source decay. The 3440 gauge should be turned on and allowed to go through the self-test (RAM TEST) before beginning. (NOTE: It is very important that the RAM TEST display has ended before proceeding. During the test, the screen will display a count down from 300 seconds and then display READY on the screen.) Place the reference block on a flat surface with a minimum density of 100 lb/ft^3 at least 10 feet from any structure and 33 feet from any other radioactive source, in the same manner as when using any other model gauge. Place the gauge on the reference block, making sure that it is seated flat and within the raised edges, with the right side of the gauge pushed firmly against the metal plate on the block. Press STANDARD on the finger keypad for the display:

Standard Count DS= MS= Take new count?

Press YES for the display:

Is the gauge STD. Block & Source rod in SAFE pos?

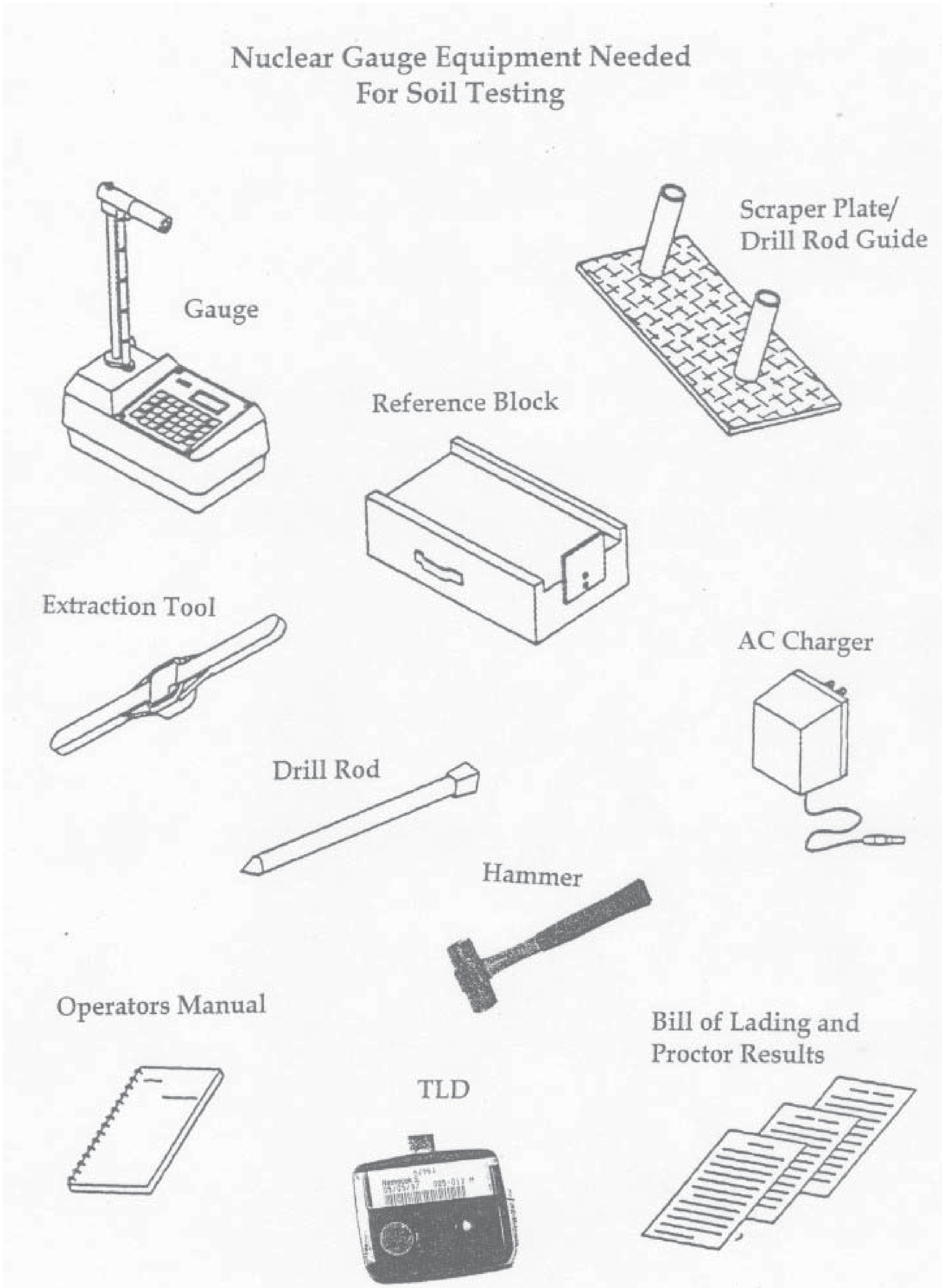
Press YES for the display:

Taking Standard Count - - seconds remaining.

After the countdown, the display is:

MS= - -.- - %P DS= - -.- - %p Do you want to use the new STD?

Press yes to enter the new counts into memory. NOTE: If the screen displays an F instead of a %P, first look to see if you are too close to any structure or another gauge. Then press NO and take a new set of counts. If the second set fails, press YES and take 3 new standard counts. Refer to the gauge manual for more detailed instructions.


Nuclear Gauge Equipment Needed
For Soil Testing
Gauge
Scraper Plate/
Drill Rod Guide
Reference Block
Extraction Tool
AC Charger
Drill Rod
Hammer
Operators Manual
Bill of Lading and
Proctor Results
TLD

NUCLEAR TESTING PROCEDURES FOR EMBANKMENTS

A construction project presents various situations in which compaction data is required. Depending upon the material to be tested, there are different testing methods that can be used to obtain the data. One method is used for testing embankment and subgrades; while another method is used for aggregate base, subbase, and select material and asphalt concrete.

When performing a test, some preliminary test information must be obtained by conducting a One-Point Proctor Test. This test establishes the maximum obtainable density and optimum moisture content. This test should be run while the contractor is compacting the soil layer to be tested.

If an appreciable amount of + 4 material (rock fragment, gravel, shale, etc.) is noticed in the soil layer, refer to VTM-1 and 12, for proper instruction. Contact the District Materials Engineer's Office for the specific gravity of + 4 material when encountered.

RECOMMENDED NUCLEAR TEST PROCEDURES FOR DETERMINING DENSITY AND MOISTURE ON EMBANKMENT AND SUBGRADES

1. First, the test site must be properly selected and prepared. Choose a test site on the compacted layer of soil or soil mixture represented by the One-Point Proctor Test. Standard Counts should have been taken in the morning and are good for that day's use.

2. Turn the gauge on to allow the device to warm up before testing is to begin. This should be done while the test site is being prepared for testing.

3. To obtain accurate results, the nuclear device must be seated flush on the compacted layer of soil. Level an area to place the device, either with a shovel or the scraper plate. If significant voids remain in the area where the device is to be placed, the voids should be filled with small amounts of soil common to the site, and lightly tamped in place with the scraper plate and excess material removed.

4. To take a Direct Transmission Density Test and a Moisture Test follow the procedure listed below.

   a. Place the drill rod guide on the test site and insert the drill rod into the guide sleeve. Place one foot on the drill rod guide to keep it in position. Drive the rod 2 inches deeper than the depth of test.

   b. Carefully remove the rod and drill rod guide. Place the gauge over the hole and extend the source rod into the hole to the required test depth. This should be done in a manner which prevents the source rod from disturbing the sides of the hole.

   c. Make sure that the gauge is resting flush on the surface and that the source rod is in the locked position. Gently pull on the gauge housing so that the extended source rod will be tight against the hole.

   d. Confirm that the gauge is on and depress "TIME" on the keypad and select one minute. The display panel will read COUNT TIME 1 min. and will return to "READY". Depressing "SHIFT 8" on the keypad will allow you to select the Soils Mode and the display will read "READY".

e. To begin the test press "START/ENTER". After the gauge completes its count the display will show %PR (Percent Compaction), DD (Dry Density), WD (Wet Density), M (Moisture) and %M (Moisture Content). Record these figures on the TL-124.

f. Now that the direct transmission and moisture tests are completed, gently retract handle to the safe position, turn the power switch off, return the device to the field carrying case, and complete Form TL-124.

Taking tests in the Backscatter Position (Asphalt and Aggregate Only)

5. If for any reason a backscatter-density and moisture test is required by the Materials Engineer or representative of the Materials Division, follow the procedure listed below.

    a. Place the device on the prepared test site and lower the handle to the BACKSCATTER position.

    b. With the "TIME" set on 1 minute depress "START/ENTER" button.

    c. When the display appears record the results on the TL-124.

Only use this method of test when instructed by District Materials Technicians.

NOTE: When making density tests in close places, such as trenches and sidewalls, background effects will be encountered that will give incorrect density moisture counts. If this occurs, see instruction for background calculations on page 36 of this chapter.

Filling out the TL – 124

1. Fill in Line E (Maximum Dry Density) which is transferred from Line G of the One-Point Proctor (Form TL-125).

    Fill in Line F (Optimum Moisture) which is transferred from Line H of the One-Point Proctor (Form TL-125).

2. Fill in Lines A through D and Line J using the information on the 3440 Display Screen.

3. Fill in Line K (Percent Minimum Density Required). Density Requirements are located in Appendix C.

Lines G, H & I are only used when +4 material has been encountered. When 10% or more +4 material is encountered the dry density (Line C) is divided by the Corrected Maximum Dry Density (Line H) and multiplied by 100 to obtained the percent compaction. (See Line J.)

Also when 10% or more +4 material is encountered it is necessary to do a moisture correction which will be entered on Line I. This will be discussed in Chapter 7.

TL-124

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)

English Metric

Report No.: ______________________ Date: ________________ Sheet No.: __1__of ___1____

Route No.: ________17____ County: _Campbell______

Project No.: _______0017-015-104,C503____

F.H.W.A. No.: ______None____

Test For: __________Embankment____

Nuclear Gauge Model No.: __3440__ Serial No.: _23456__ Calibration Date: ______________

STANDARD COUNT	
DENSITY	MOISTURE
2830	701

Test No.	1			
Location of Test — Station ft. (m)	585 + 00			
Ref. to center line ft. (m)	At C/L			
Elevation	+8 / -4			
Compacted Depth of Lift in. (mm)	6”			
Method of Compaction	Sheepsfoot			
A. Wet Density (lbs/ft³), Wet Unit Mass (kg/m³)				
B. Moisture Unit Mass (lbs/ft³), Moisture Unit Mass (kg/m³)				
C. Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) (A - B)				
D. Moisture Content (B ÷ C) x 100				
E. Maximum Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) Lab Proctor or One Point Proctor	124.2			
F. Percent Optimum Moisture from Lab or One Point Proctor	10.7 8.6 – 12.8			
G. Percent of plus #4, (plus 4.75mm)				
H. Corrected Maximum Dry Density (lbs/ft³) Dry Unit Mass (kg/m³)				
I. Corrected Optimum Moisture				
J. Percent Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) (C ÷ E) x 100 or (C ÷ H) x 100				
K. Percent Minimum Density Required =				

1. From One-Point Proctor Results

(TL-125 Line G)

Moisture and Range (TL-125 Line H)

Remarks:

CC: District Materials Engineer
Project File

By: ____________________________________

Title: ____________________________________

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)

English Metric

Report No.: ______________ Date: ______________ Sheet No.: 1 of 1

Route No.: 17 County: Campbell

Project No.: 0017-015-104,C503

F.H.W.A. No.: None

Test For: Embankment

Nuclear Gauge Model No.: 3440 Serial No.: 23456 Calibration Date: ______________

STANDARD COUNT	
DENSITY	MOISTURE
2830	701

Test No.		1			
Location of Test	Station ft. (m)	585 + 00			
	Ref. to center line ft. (m)	At C/L			
	Elevation	+8 / -4			
Compacted Depth of Lift in. (mm)		6”			
Method of Compaction		Sheepsfoot			
A. Wet Density (lbs/ft^3), Wet Unit Mass (kg/m^3)	=	133.3			
B. Moisture Unit Mass (lbs/ft^3), Moisture Unit Mass (kg/m^3)	=	12.8			
C. Dry Density (lbs/ft^3), Dry Unit Mass (kg/m^3) (A - B)	=	120.5			
D. Moisture Content (B ÷ C) x 100	=	10.6			
E. Maximum Dry Density (lbs/ft^3), Dry Unit Mass (kg/m^3) Lab Proctor or One Point Proctor	=	124.2			
F. Percent Optimum Moisture from Lab or One Point Proctor	=	10.7 8.6 – 12.8			
G. Percent of plus #4, (plus 4.75mm)	=				
H. Corrected Maximum Dry Density (lbs/ft^3) Dry Unit Mass (kg/m^3)	=				
I. Corrected Optimum Moisture	=				
J. Percent Dry Density (lbs/ft^3), Dry Unit Mass (kg/m^3) (C ÷ E) x 100 or (C ÷ H) x 100	=	97.0			
K. Percent Minimum Density Required	=	95.0			

2. From 3440 Display Screen

% PR = 97.0
DD = 120.5
WD = 133.3
M = 12.8 %M = 10.6

Lines G, H & I used only for +4 corrections

3. Density Requirements located in Apendix C

Remarks:

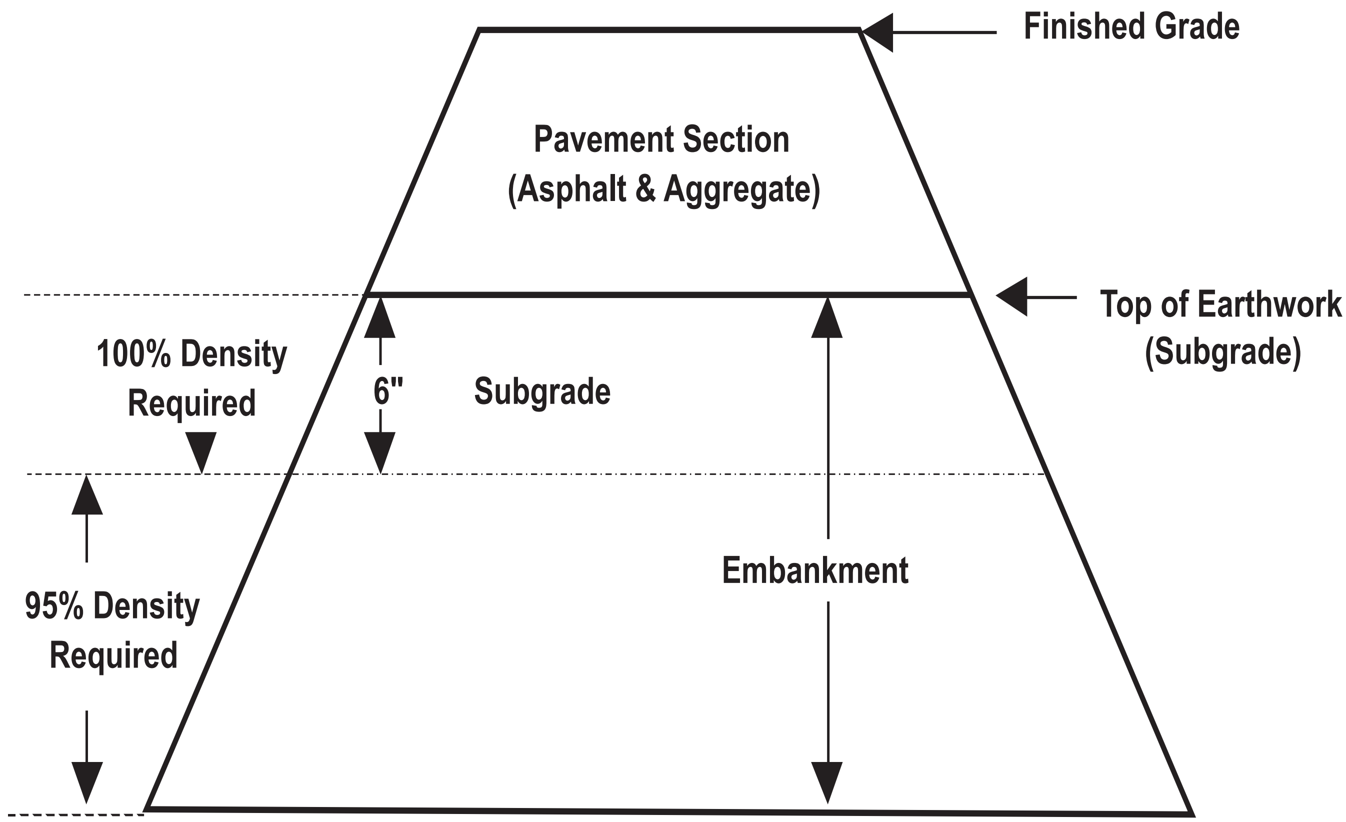
CC: District Materials Engineer
Project File

By: ______________________

Title: ______________________

ARE SPECIFICATIONS MET?

The actual density specification will vary with the vertical location of the material in the embankment and with the amount of plus No. 4 material within the fill (see below).



VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)

English Metric

Report No.: ____________ Date: ____________ Sheet No.: 1 of 1

Route No.: 17 County: Campbell

Project No.: 0017-015-104,C503

F.H.W.A. No.: None

Test For: Embankment

Nuclear Gauge Model No.: 3440 Serial No.: 23456 Calibration Date: ____________

DENSITY
2830

Correcting Density Tests for High Moisture with the Speedy Moisture Tester

Test No.		2E			
Location of Test	Station ft. (m)	585 + 00			
	Ref. to center line ft. (m)	At C/L			
	Elevation	+6 / -5			
Compacted Depth of Lift in. (mm)		6”			
Method of Compaction		Sheepsfoot			
A. Wet Density (lbs/ft³), Wet Unit Mass (kg/m³)	=	139.0			
B. Moisture Unit Mass (lbs/ft³), Moisture Unit Mass (kg/m³)	=	18.1			
C. Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) (A - B)	=	120.9			
D. Moisture Content (B ÷ C) x 100	=	15.0			
E. Maximum Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) Lab Proctor or One Point Proctor	=	129.3			
F. Percent Optimum Moisture from Lab or One Point Proctor	=	9.2 7.4 – 11.0			
G. Percent of plus #4, (plus 4.75mm)	=				
H. Corrected Maximum Dry Density (lbs/ft³) Dry Unit Mass (kg/m³)	=				
I. Corrected Optimum Moisture	=				
J. Percent Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) (C ÷ E) x 100 or (C ÷ H) x 100	=	93.5			
K. Percent Minimum Density Required	=	95.0			

Moisture Content from Nuclear gauge is suspected to be incorrect (→ D. Moisture Content)

Remarks:

CC: District Materials Engineer
Project File

By: ____________

Title: ____________

TL-124

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)

English Metric

Report No.: ______ No.: 1 of 1

Route No.: ______ ...ty: Campbell

Project No.: ______

F.H.W.A. No.: ______

Test For: ______

Correcting Density Tests for High Moisture with the Speedy Moisture Tester

Nuclear Gauge Model No.: 3440 Serial No.: 23456 Calibration Date: ______

STANDARD COUNT

DENSITY	MOISTURE
2830	701

Test No.		2E			
Location of Test	Station ft. (m)	585 + 00			
	Ref. to center line ft. (m)	At C/L			
	Elevation	+6 / -5			
Compacted Depth of Lift in. (mm)		6"			
Method of Compaction		Sheepsfoot			
A. Wet Density (lbs/ft³), Wet Unit Mass (kg/m³)	=	139.0			
B. Moisture Unit Mass (lbs/ft³), Moisture Unit Mass (kg/m³)	=	12.4			
C. Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) (A - B)	=	126.6			
D. Moisture Content (B ÷ C) x 100	=	9.8			
E. Maximum Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) Lab Proctor or One Point Proctor	=	129.3			
F. Percent Optimum Moisture from Lab or One Point Proctor	=	9.2 7.4 – 11.0			
G. Percent of plus #4, (plus 4.75mm)	=				
H. Corrected Maximum Dry Density (lbs/ft³) Dry Unit Mass (kg/m³)	=				
I. Corrected Optimum Moisture	=				
J. Percent Dry Density (lbs/ft³), Dry Unit Mass (kg/m³) (C ÷ E) x 100 or (C ÷ H) x 100	=	97.9			
K. Percent Minimum Density Required	=	95.0			

1. Moisture Content using Speedy Moisture Tester

2. Calculate Dry Density

$$\frac{\text{Wet Density}}{1 + \text{\% Moisture (as a decimal)}}$$

$$\frac{139.0}{1.098} = 126.6 \text{ lb/ft}^3$$

3. Calculate Moisture Unit Weight

Wet Density – Dry Density = Moisture Unit Weight

139.0 - 126.6 = 12.4 lb/ft³

Remarks:

Speedy Moisture Used Due to Micaceous Soil
Dial Reading 8.9

4. Don't forget to note in remarks as this deviates from normal procedure

CC: District Materials Engineer
Project File

By: ______

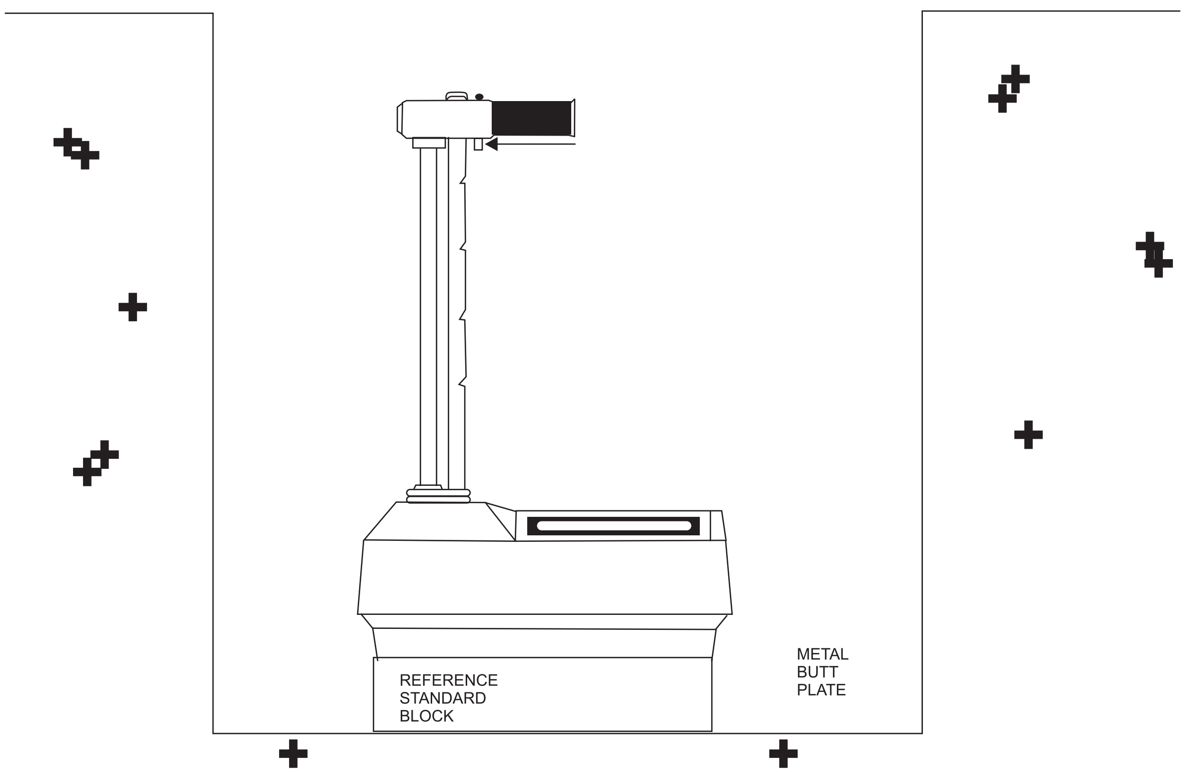
Title: ______

BACKGROUND CALCULATIONS FOR TRENCH AND SIDEWALL MOISTURE TESTING

When a 3440 Nuclear Gauge is operated within 24 inches of a vertical structure the density and moisture counts will be affected due to gamma photons and neutrons echoing off the walls of the structure. It is necessary to perform a trench offset when testing backfill material around pipe culverts, abutments, near a building, etc. This correction should be performed each day and when trench wall conditions (distance from wall, moisture content, material composition, etc.) vary.

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

1. Take the daily standard count with the gauge on the Standard Block outside the trench and record the density and moisture values.
2. Place the gauge on the Standard Block inside the trench in the testing area and press “OFFSET” on the display panel and select No. 3 “TRENCH OFF” The gauge will show Trench Offset Disabled and ask if you want to use Trench Offset. Press “YES”. The gauge will show trench offset for moisture and density and ask if you want to change. Press “YES” to perform a new offset and “NO” to use the existing offset constants. If you selected yes, the gauge will prompt you to press “START” for 1 minute Standard Counts in trench. Make sure to take counts the same distance from the wall as the anticipated test readings. The density and moisture trench offset constants will be calculated and stored. When the gauge is not to be used for trench measurements disable the offset.



Gauge and Reference Standard Block Position for Trench Offset

SELF REGULATIONS & THE VDOT LICENSE

VDOT has a Materials Liscense issued by the Virginia Department of Health (VDH). The VDH is responsible for ensuring the safety of people who work with radioactive by-product materials and the security of such materials. To control the risks associated with the use of nuclear by-product materials, the VDH sets strict health and safety standards for nuclear equipment, defines allowable limits for radiation exposure and frequently conducts inspections of nuclear products and facilities. The VDH enforces the Code of Federal Regulations and all applicable state requirements governing the use of radioactive by-product materials. The codes are Federal and state law and they are binding upon licensees to uphold.

In addition to the Codes of Federal Regulation (CFR), licensee are governed by the provisions outlined in the license authorizing the possession of by-product material. The possession of a license obligates the Department to scrupulously perform the actions it stated it would perform to comply with the requirements of it license. This commitment is the condition under which the Department is able to receive and then retain the license. Failure to comply could mean a severe fine, loss of license, or both, together with the adverse publicity. The provisions of the license are just as compelling as the C.F.R. govern nuclear safety.

Possession of a VDH license requires the licensee to adhere to safe practices and act as self-regulator in the enforcement of regulations. This Agency is compelled to report its own infraction of rules to the VDH. To enforce these safety regulations periodic checks on the program to see that VDOT's employees are following Department's instructions and radiation safety rules are an essential part of safe operations of nuclear gauges. VDOT has established a system of records covering the receipt and transfer of nuclear gauges. We must maintain records of radiation exposure of persons working in the program and surveys are conducted to evaluate the effectiveness of radiation safety programs.

STORAGE REQUIREMENTS

1. "Radioactive Material" signs shall be posted in the storage unit on the inside of the door in accordance with Virginia Department of Health Radiation Protection Regulations.

2. The Form "Notice to Employees," shall be posted on the project bulletin board where the nuclear gauge is assigned, in accordance with Virginia Department of Health Radiation Protection Regulations.

3. The radioactive source when not in use and when left unattended shall be stored and secured (locked, bolted, etc.) at all times against unauthorized removal from the storage place, in accordance with Virginia Department of Health Radiation Protection Regulations. The magenta and yellow "**FEDERAL OFFENSE**" sign shall be posted on the locked blue carrying case while the nuclear gauge is being stored. The intent of this sign is to discourage the theft of the gauge.

4. VDOT requires that an outside storage facility be used and that it be at least 10 feet from personnel's permanent workstation (desk). See Road and Bridge Specification Section 514.02 (c).

5. The nuclear gauge and TLD's (Film Badge) stored shall be at least 10 feet apart. Badges shall be stored in designated area inside project trailer.

6. The required records of transfer shall be completed when the nuclear gauge is in transit on the project site by using log sheet located in the storage facility on the project site, or moved from one assigned area to another or when transferred to another license.

NUCLEAR GAUGE CALIBRATIONS

The source decays at a rate of 2.2% per year and the electronics have a minor amount of drift from aging parts. Therefore, gauges are calibrated in the laboratory at least yearly under controlled conditions using the same methods of testing as in the field. The gauges are calibrated on a series of blocks of known density and moisture contents.

This is for your information--do not proceed with gauge maintenance unless you have had the proper safety training.

NUCLEAR GAUGE MAINTENANCE

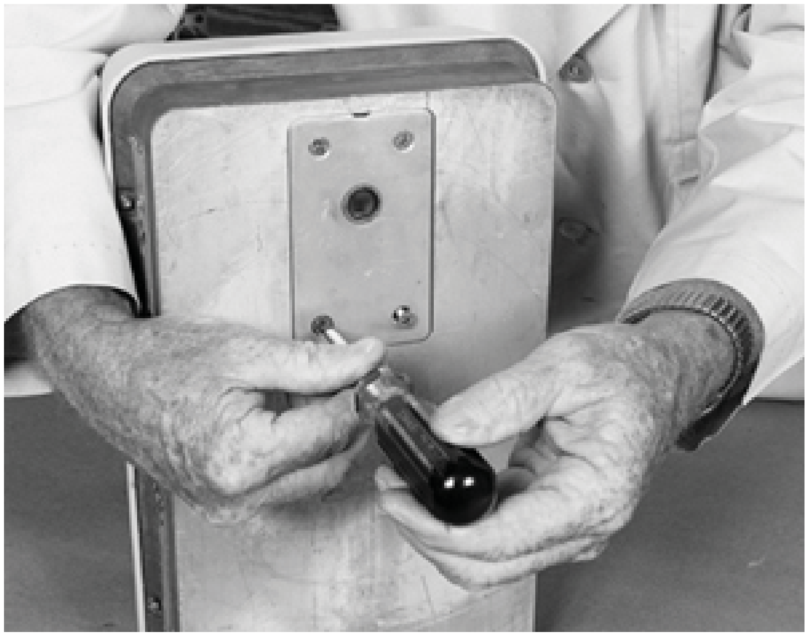
Cleaning

The source rod in the 3400 Series is supported in linear bearings packed with Magnalube-G grease. The grease is retained within the bearings and soil kept out by a system of wipers and seals at the top and bottom of the center post of the gauge. These bearings will require little or no service, unless the gauge is overhauled. Do not lubricate.

On the bottom surface of the gauge is a removable plate with a brass scraper ring mounted in it. This ring will remove most of the soil from the source rod. However, under some soil conditions, small amounts will be carried into the sliding shield assembly. If allowed to build up, this soil can cause wear in the shield cavity and can ultimately be forced into the bearings and ruin them.

Cleaning the cavity is relatively simple. Place the gauge on its side on a bench with the base away from the operator. The source rod should be latched in the SAFE position. Using a Phillips screwdriver, remove the four screws holding the bottom plate assembly in position and pry out the assembly using a flat blade screwdriver. Using the same tool, remove the sliding block and spring.

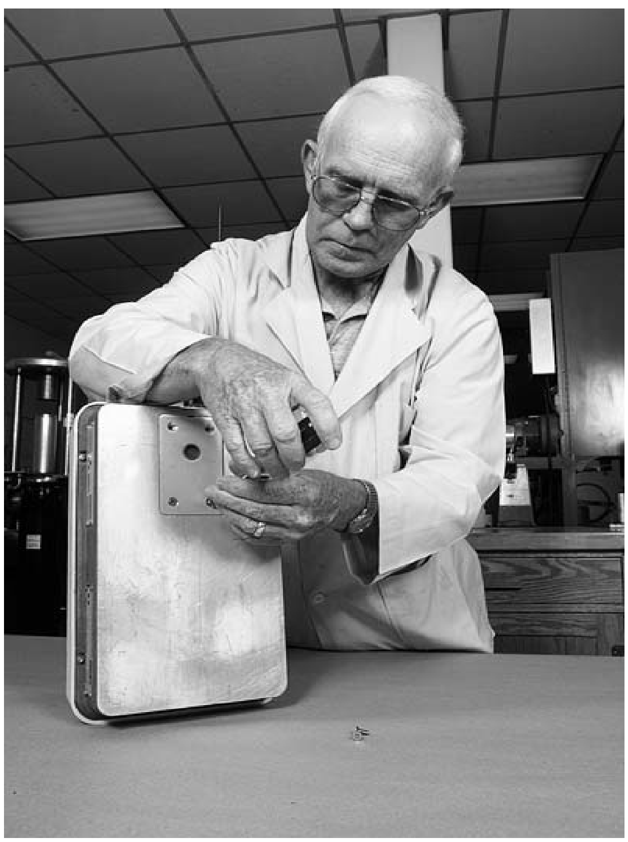
Using a rag, stiff brush and compressed air, if available, remove all soil and wipe clean the cavity, sliding block and bottom plate assembly. Inspect all items for excessive wear and replace if required. Check the scraper ring to insure that it is free to move in its groove. If the ring is damaged it may be replaced or replace the assembly. The cleaning time will take no longer than five minutes.



Stand gauge on the end and stand behind the gauge to work. Remove screws from the bottom plate.

Remove the bottom plate and the tungsten sliding block that shields the source rod.

Clean the area around the tungsten block and clean and polish the face of the block to remove all rough surface. Do not get hands near the source rod.



Replace the block and plate. Clean the gauge when difficulty is encountered when lowering and raising the source rod.

Battery Charging for Model 3440

A fully charged battery will last approximately 8 weeks under normal working conditions (8 hr. day). The 3440 display panel will give you the hours remaining on the current charge, and when it is running low, the screen will display BATTERIES LOW! You still have a few hours left when this display occurs in order to finish the current test. At the completion of the days testing, the gauge needs to be plugged in overnight to fully recharge. IMPORTANT : Only recharge when the gauge indicates that it is low. Needless recharging will shorten the battery life.

Alkaline Battery Use

Alkaline batteries may be used when recharging is not an option. The gauge has a separate battery case for this purpose. Refer to manual for further instructions.

CAUTION: Never mix alkaline and rechargeable batteries in the gauge. They may explode when charging!!!

INSTRUCTIONS TO FOLLOW IN THE EVENT OF AN ACCIDENT
DO NOT DISCUSS INCIDENT WITH ANYONE EXCEPT POLICE, STATE MATERIALS PERSONNEL, AND YOUR IMMEDIATE SUPERVISOR.
The District Public Relations Specialist must address all news media questions.

1. Stop and detain all equipment or vehicles involved until the assessment can be made to determine if there is any contamination. If a vehicle is involved, notify the local and state police. Let them know that radioactive materials are involved. Segregate and detain all persons involved.

2. Assess and treat life-threatening injuries immediately. Do not delay advanced life support if victims cannot be moved. Move victims away from the radiation hazard area if possible, using proper patient transfer techniques to prevent further injury. Stay within the controlled area if contamination is suspected.

3. Prohibit eating, drinking, or smoking by persons while at the accident scene.

4. Locate the gauge and or source, see attached check list.

5. Immediately cordon off at least a 20 feet radius surrounding the gauge and parts, if any. Keep on-lookers and all unnecessary personnel at a safe distance, while caring for or rescuing any persons who are injured.

6. Notify the nearest Radiation Safety Officer of the license holder to come and monitor the device to determine if there is possible leakage. (Give good directions as to location of accident.)

7. Never let anyone remove the gauge, equipment or any articles that are involved in the accident until the area has been cleared by a monitoring team.

8. Complete the Nuclear Accident Checklist located in the Bill of Lading after the RSO or monitoring team has arrived and assessed the situation. The Emergency Notification List is also in the Bill of Lading.

Nuclear Testing Flowchart

Pretest and Warm Up Procedures

1. Clean Gauge (if needed)
2. Warm Up Gauge (300 sec.)
3. Standard Counts
   (daily calibration)
4. Charge if Needed
   (16 hour minimum except in
   emergency such as roller pattern)

Equipment Needed

For Soils Testing

1. Film Badge
2. Bill of Lading
3. Plate
4. Pin
5. Hammer
6. Proctor Results
7. Speedy Moisture
   (if testing micaceous soils or other
   Material with high hydrogen content)
8. Proper Form (VDOT TL-124A)

For Base and Subbase

1. Film Badge
2. Bill of Lading
3. Control Strip Target Densities
4. Proper Forms
   TL-53A for Roller Pattern
   TL-54A for Control Strip
   TL-55A for Acceptance Testing

Test Site Preparation

For Soils Testing

1. Construction Plans (as an aid in
   choosing test sites in proposed fills)
2. Blade off area (fill in voids with -4
   material)

For Base and Subbase

1. Choose representative site
   (not an area with only coarse or
   only fine material)
2. DO NOT fall into a routine
   (randomize testing pattern and
   frequency)

Testing

Soils

1. Set time control (1 min. for all testing
   except roller patterns)
2. Pull gauge back
3. Push start button
4. **STEP BACK - at least two paces**
5. Direct Transmission Position for soils

Base and Subbase

1. Set time control (1 min. for all testing
   except roller patterns)
2. Push start button
3. **STEP BACK - at least two paces**
4. Backscatter Position
   for base and subbase material

Record Counts

1. TL-124A for Direct Transmission
2. TL-53A for Roller Pattern
3. TL-54A for Control Strip
4. TL-55A for Acceptance Tests
   (on all forms moisture counts are taken on soil and aggregate only)

Accept Test Results

All tests are accepted based on their comparison to known TARGET densities and moisture.

Soil test are compared to PROCTOR Results: Moisture range for Acceptance is +/- 20 % of optimum moisture. Density range is 95% for embankment and pipe backfill and 100% for subgrade. (See Appendix C.)

Base and subbase material is compared to control strip test results: Density range is a minimum of 95% for each individual reading and 98% for an average of the same 5 readings. (Note: 5 readings equal one test.)

TROUBLESHOOTING GUIDE FOR THE NUCLEAR MOISTURE/DENSITY GAUGE

PROBLEM	PROBABLE CAUSE	SOLUTION
Gauge turns off after it is turned on or will not turn on	1. Gauge may be wet. DO NOT turn gauge on until it has dried. 2. Batteries are low	1. Wait until gauge dries off. 2. Recharge batteries minimum of 16 hours (short and frequent charge drains battery life). If charge doesn't hold call District Materials Section.
Short battery life	1. Bad outlet. 2. Batteries are reaching end of cycle or charge isn't working.	1. Check outlet. 2. Call the District Materials Section.
Questionable Standard Counts	1. Gauge needs more warm-up time or isn't properly seated on the standard block. 2. Handle isn't in the safe position. 3. Background interference.	1. Check to see that the gauge isn't on the standard block backwards. Clean all dirt, gravel, etc. from the gauge standard or test block. Make sure these counts are taken exactly as all prior tests. 2. Check handle position 3. Move away from any large structures.
Questionable moisture Counts.	1. Mica, asbestos or other hydrogen rich material is in soil.. 2. Background interference from large structure or trench wall if below ground level. 3. Internal tube failure 4. Handle not locked in testing position notch	1. Run a Speedy Moisture test. 2. Move test site away from structures or run background count if testing in a trench. 3. Run new standard count to check gauge. 4. Check handle position
Questionable density Counts	1. Presence of +4 material. 2. Test isn't taken on soil represented by Proctor test result. 3. Internal tube failure 4. Handle isn't locked into testing position	1. Check for +4 material and take corrective action that applies to your District 2. Run a Proctor test. 3. Run new standard counts. 4. Check handle position

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CHAPTER 6
Practice Problems

Practice Problem 1
Density Testing with the Sand Cone

1) Use the TL-125 to complete the following embankment density test from the information provided below.

   Unit Weight of Sand = 86.5 lb/ft^3
   Weight of Sand + Jar + Cone = 15.80 lb.
   Weight of Sand Left in Jar + Weight of Jar & Cone = 7.89 lb.
   Weight of Sand in Cone and Base Plate = 2.77 lb.
   Weight of Wet Soil from hole + Weight of Pan = 9.10 lb.
   Weight of Pan = 1.67 lb.
   Moisture Content from Speedy = 14.7%

   Proctor Information
   Maximum Dry Density = 107.1 lb/ft^3
   Optimum Moisture Content = 17.6%

2) Answer the following questions:

   a) Does this test pass?

   b) Would this test pass for subgrade?

   c) Assume that the soil removed from the hole contains two (2) small rocks about the size of a dime. What should you do?

TL-125 Rev. 6/00

VIRGINIA DEPARTMENT OF TRANSPORTATION
REPORT OF SAND CONE DENSITY (UNIT MASS OF SOIL)

English ☐ Metric ☐

Report No.: 1 Date: ____

Route No.: 635 County: Amherst

Project No.: 0635-005-187,C501 FHWA No.: FH-151(102)

Field Test No.		1		
Location of Test	Station ft. (m.)	77 + 50		
	Ref. To Center Line ft. (m.)	7′ Lt. C/L		
Reference Elevation	Original Ground ft. (m.)	+10′		
	Finished Grade ft. (m.)	-23′		
Compacted Depth of Lift in. (mm.)		6″		
Method of Compaction (Type of Roller)		Sheepsfoot		
DENSITY DETERMINATION				
A. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of sand (calibrated value)				
B. Wt. (mass) sand + wt. (mass) of jar and cone, lb. (kg)				
C. Wt. (mass) sand left in jar + wt. (mass) of jar and cone, lb. (kg)				
D. Wt. (mass) of sand in cone and base plate, lb. (kg) (calibrated value)				
E. Wt. (mass) sand left in jar + wt. (mass) of jar and cone + wt. (mass) of sand in cone and base plate (C + D), lb.(kg)				
F. Wt. (mass) of sand in test hole (B - E), lb. (kg)				
G. Volume of test hole (F ÷ A), ft^3 (m^3)				
H. Wt. (mass) of wet soil from test hole + (wt.) mass of pan, lb. (kg)				
I. Wt. (mass) of pan, lb. (kg)				
J. Wt. (mass) of wet soil from test hole (H - I), lb. (kg)				
K. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of wet soil in fill (J ÷ G)				
L. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of dry soil in fill = $\frac{K}{\{1 + [\text{Moisture Content (T)} \div 100]\}}$				
M. Max. Dry Unit Wt.(lbs/ft^3) or Unit mass (kg/m^3) from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)				
N. Optimum Moisture Content from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)				
O. Percent of +No. 4 (plus 4.75 mm) Material				
P. Corrected Maximum Dry Unit wt. (lbs/ft^3) or Unit mass (kg/m^3)				
Q. Corrected Optimum Moisture (%)				
R. % Compaction (L ÷ M) × 100 or (L ÷ P) × 100				
S. % Minimum density (unit mass) required (from specifications)				
MOISTURE DETERMINATION (For Field Dried Method)				
a. Dish and damp soil, lb. (kg)				
b. Dish and dried soil, lb. (kg)				
c. Wt. (mass) moisture (a - b), lb. (kg)				
d. Wt. (mass) dish, lb. (kg)				
e. Wt. (mass) dry soil (b - d), lb. (kg)				
T. Moisture Content (c ÷ e) × 100 or from "Speedy" Moisture Test				

Remarks: ____ By: ____

Title: ____

cc: District Materials Engineer
Project File

CHAPTER 6
Practice Problem 2
Density Testing with the Sand Cone

1) Use the TL-125 to complete the following embankment density test from the information provided below.

Unit Weight of Sand = 86.5 lb/ft^3
Weight of Sand + Jar +Cone = 13.30 lb.
Weight of Sand Left in Jar + Weight of Jar & Cone = 5.10 lb.
Weight of Sand in Cone and Base Plate = 2.77 lb.
Weight of Wet Soil from Hole + Weight of Pan = 9.36 lb.
Weight of Pan = 1.67 lb.
Moisture Content from Speedy = 19.4%

Proctor Information
Maximum Dry Density = 102.4 lb/ft3
Optimum Moisture Content = 20.3%

2) Does this test pass?

TL-125 Rev. 6/00

VIRGINIA DEPARTMENT OF TRANSPORTATION
REPORT OF SAND CONE DENSITY (UNIT MASS OF SOIL)

English ☐ Metric ☐

Report No.: 3 Date: ______

Route No.: 0635 County: Amherst

Project No.: 0635-005-187,C501 FHWA No.: FH-151(102)

Field Test No.	2			
Location of Test — Station ft. (m.)	87 + 50			
Location of Test — Ref. To Center Line ft. (m.)	10’ Rt. C/L			
Reference Elevation — Original Ground ft. (m.)	+20’			
Reference Elevation — Finished Grade ft. (m.)	-23’			
Compacted Depth of Lift in. (mm.)	6”			
Method of Compaction (Type of Roller)	Sheepsfoot			
DENSITY DETERMINATION				
A. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of sand (calibrated value)				
B. Wt. (mass) sand + wt. (mass) of jar and cone, lb. (kg)				
C. Wt. (mass) sand left in jar + wt. (mass) of jar and cone, lb. (kg)				
D. Wt. (mass) of sand in cone and base plate, lb. (kg) (calibrated value)				
E. Wt. (mass) sand left in jar + wt. (mass) of jar and cone + wt. (mass) of sand in cone and base plate (C + D), lb.(kg)				
F. Wt. (mass) of sand in test hole (B - E), lb. (kg)				
G. Volume of test hole (F ÷ A), ft^3 (m^3)				
H. Wt. (mass) of wet soil from test hole + (wt.) mass of pan, lb. (kg)				
I. Wt. (mass) of pan, lb. (kg)				
J. Wt. (mass) of wet soil from test hole (H - I), lb. (kg)				
K. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of wet soil in fill (J ÷ G)				
L. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of dry soil in fill = $\frac{K}{\{1 + [\text{Moisture Content (T)} \div 100]\}}$				
M. Max. Dry Unit Wt.(lbs/ft^3) or Unit mass (kg/m^3) from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)				
N. Optimum Moisture Content from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)				
O. Percent of +No. 4 (plus 4.75 mm) Material				
P. Corrected Maximum Dry Unit wt. (lbs/ft^3) or Unit mass (kg/m^3)				
Q. Corrected Optimum Moisture (%)				
R. % Compaction (L ÷ M) × 100 or (L ÷ P) × 100				
S. % Minimum density (unit mass) required (from specifications)				
MOISTURE DETERMINATION (For Field Dried Method)				
a. Dish and damp soil, lb. (kg)				
b. Dish and dried soil, lb. (kg)				
c. Wt. (mass) moisture (a - b), lb. (kg)				
d. Wt. (mass) dish, lb. (kg)				
e. Wt. (mass) dry soil (b - d), lb. (kg)				
T. Moisture Content (c ÷ e) × 100 or from “Speedy” Moisture Test				

Remarks: ______

By: ______

Title: ______

cc : District Materials Engineer
Project File

CHAPTER 6
Practice Problem 3
Density Testing with the Sand Cone

1) Use the TL-125 to complete the following embankment density test from the information provided below.

Unit Weight of Sand = 86.2 lb/ft^3
Weight of Sand + Jar + Cone = 16.0 lb.
Weight of Sand Left in Jar + Weight of Jar & Cone = 7.69 lb.
Weight of Sand in Cone and Base Plate = 2.75 lb.
Weight of Wet Soil from Hole + Weight of Pan = 8.77 lb.
Weight of Pan = 1.65 lb.
Moisture Content from Speedy = 15.8%

Proctor Information
Maximum Dry Density = 104.7 lb/ft3
Optimum Moisture Content = 19.2%

2) Does this test pass?

TL-125 Rev. 6/00

VIRGINIA DEPARTMENT OF TRANSPORTATION
REPORT OF SAND CONE DENSITY (UNIT MASS OF SOIL)

English ☐ Metric ☐

Report No.: 40 | Date:
Route No.: 615 | County: Campbell
Project No.: 0615-015-186,C501 | FHWA No.: FH-132(104)

Field Test No.		20		
Location of Test	Station ft. (m.)	87 + 40		
	Ref. To Center Line ft. (m.)	10’ Rt. C/L		
Reference Elevation	Original Ground ft. (m.)	+13’		
	Finished Grade ft. (m.)	-7’		
Compacted Depth of Lift in. (mm.)		6”		
Method of Compaction (Type of Roller)		Sheepsfoot		
DENSITY DETERMINATION				
A. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of sand (calibrated value)				
B. Wt. (mass) sand + wt. (mass) of jar and cone, lb. (kg)				
C. Wt. (mass) sand left in jar + wt. (mass) of jar and cone, lb. (kg)				
D. Wt. (mass) of sand in cone and base plate, lb. (kg) (calibrated value)				
E. Wt. (mass) sand left in jar + wt. (mass) of jar and cone + wt. (mass) of sand in cone and base plate (C + D), lb.(kg)				
F. Wt. (mass) of sand in test hole (B - E), lb. (kg)				
G. Volume of test hole (F ÷ A), ft^3 (m^3)				
H. Wt. (mass) of wet soil from test hole + (wt.) mass of pan, lb. (kg)				
I. Wt. (mass) of pan, lb. (kg)				
J. Wt. (mass) of wet soil from test hole (H - I), lb. (kg)				
K. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of wet soil in fill (J ÷ G)				
L. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of dry soil in fill = $\frac{K}{\{1 + [\text{Moisture Content (T)} \div 100]\}}$				
M. Max. Dry Unit Wt.(lbs/ft^3) or Unit mass (kg/m^3) from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)				
N. Optimum Moisture Content from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)				
O. Percent of +No. 4 (plus 4.75 mm) Material				
P. Corrected Maximum Dry Unit wt. (lbs/ft^3) or Unit mass (kg/m^3)				
Q. Corrected Optimum Moisture (%)				
R. % Compaction (L ÷ M) × 100 or (L ÷ P) × 100				
S. % Minimum density (unit mass) required (from specifications)				
MOISTURE DETERMINATION (For Field Dried Method)				
a. Dish and damp soil, lb. (kg)				
b. Dish and dried soil, lb. (kg)				
c. Wt. (mass) moisture (a - b), lb. (kg)				
d. Wt. (mass) dish, lb. (kg)				
e. Wt. (mass) dry soil (b - d), lb. (kg)				
T. Moisture Content (c ÷ e) × 100 or from “Speedy” Moisture Test				

Remarks: ______

By: ______

Title: ______

cc: District Materials Engineer
Project File

CHAPTER 6
Practice Problem 4
Density Testing with the Sand Cone

1) Use the TL-125 to complete the following embankment density test from the information provided below.

Unit Weight of Sand = 86.5 lb/ft^3
Weight of Sand +Jar + Cone = 13.29 lb.
Weight of Sand Left in Jar + Weight of Jar & Cone = 5.09 lb.
Weight of Sand in Cone and Base Plate = 2.76 lb.
Weight of Wet Soil from Hole + Weight of Pan = 9.38 lb.
Weight of Pan = 1.67 lb.
Moisture Content from Speedy = 18.8%

Proctor Information
Maximum Dry Density = 102.4 lb/ft3
Optimum Moisture Content = 20.3%

2) Does this test pass?

TL-125 Rev. 6/00

VIRGINIA DEPARTMENT OF TRANSPORTATION
REPORT OF SAND CONE DENSITY (UNIT MASS OF SOIL)

English ☐ Metric ☐

Report No.: 60 Date:

Route No.: 632 County: Amherst

Project No.: 0632-005-184,C501 FHWA No.: FH-130(101)

Field Test No.		34		
Location of Test	Station ft. (m.)	120 + 40		
	Ref. To Center Line ft. (m.)	13' Rt. C/L		
Reference Elevation	Original Ground ft. (m.)	+16'		
	Finished Grade ft. (m.)	-7'		
Compacted Depth of Lift in. (mm.)		6"		
Method of Compaction (Type of Roller)		Sheepsfoot		
DENSITY DETERMINATION				
A. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of sand (calibrated value)				
B. Wt. (mass) sand + wt. (mass) of jar and cone, lb. (kg)				
C. Wt. (mass) sand left in jar + wt. (mass) of jar and cone, lb. (kg)				
D. Wt. (mass) of sand in cone and base plate, lb. (kg) (calibrated value)				
E. Wt. (mass) sand left in jar + wt. (mass) of jar and cone + wt. (mass) of sand in cone and base plate (C + D), lb.(kg)				
F. Wt. (mass) of sand in test hole (B - E), lb. (kg)				
G. Volume of test hole (F ÷ A), ft^3 (m^3)				
H. Wt. (mass) of wet soil from test hole + (wt.) mass of pan, lb. (kg)				
I. Wt. (mass) of pan, lb. (kg)				
J. Wt. (mass) of wet soil from test hole (H - I), lb. (kg)				
K. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of wet soil in fill (J ÷ G)				
L. Unit wt.(lbs/ft^3) or Unit mass (kg/m^3) of dry soil in fill = $\frac{K}{\{1 + [\text{Moisture Content (T)} \div 100]\}}$				
M. Max. Dry Unit Wt.(lbs/ft^3) or Unit mass (kg/m^3) from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)				
N. Optimum Moisture Content from LAB PROCTOR OR ONE POINT PROCTOR (TL-125a)				
O. Percent of +No. 4 (plus 4.75 mm) Material				
P. Corrected Maximum Dry Unit wt. (lbs/ft^3) or Unit mass (kg/m^3)				
Q. Corrected Optimum Moisture (%)				
R. % Compaction (L ÷ M) × 100 or (L ÷ P) × 100				
S. % Minimum density (unit mass) required (from specifications)				
MOISTURE DETERMINATION (For Field Dried Method)				
a. Dish and damp soil, lb. (kg)				
b. Dish and dried soil, lb. (kg)				
c. Wt. (mass) moisture (a - b), lb. (kg)				
d. Wt. (mass) dish, lb. (kg)				
e. Wt. (mass) dry soil (b - d), lb. (kg)				
T. Moisture Content (c ÷ e) × 100 or from "Speedy" Moisture Test				

Remarks: By:

Title:

cc: District Materials Engineer
Project File

CHAPTER 6
Nuclear Field Density Testing of Soil
Study Questions

1. Batteries should be charged ____.

2. True or False. The nuclear gauge should be warmed-up first thing in the morning before using it.

3. True or False. The only maintenance performed in the field is cleaning the nuclear gauge and charging the batteries.

4. When taking a standard count, the nuclear gauge should be a minimum of _____ ft. from any structure and ______ ft. from any other radioactive source.

5. True or False. Cesium-137 is located in the tip of the stainless steel rod which is used in taking moisture determinations and Americium-241:Beryllium is located inside the nuclear gauge and is used for density testing.

6. When taking Standard Counts the Reference Standard should be placed on what type of surface?

7. Three ways to limit exposure to radiation are ________________________________.

8. If the soil material fails a nuclear test because of excessive moisture, the first step taken is ____.

9. A testing method for testing densities whereby the source rod is inserted into the material to be tested to a depth of either 4, 6 or 8 inches is ____ _____.

10. If, during construction, the density results either change suddenly, or simply don't make sense to you, you should ____.

11. If the moisture results from the Nuclear test appear high, the ________________ could be used to check the moisture.

12. When a nuclear gauge is operated within 24 inches of a vertical structure, the _______ and ___________________ are influenced by the structure.

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CHAPTER 6
Practice Problems
Nuclear Field Density Testing of Soil
Nuclear Method

Complete the TL-124 using the information below and determinte if tests pass.

PRACTICE PROBLEM 5

PROCTOR DATA

Maximum Dry Density 114.6 lb/ft^3
Optimum Moisture: 14.1%

3440 DISPLAY SCREEN

%PR 99.7

DD = 114.2
WD = 133.3

M = 19.1 %M = 16.7

PRACTICE PROBLEM 6

PROCTOR DATA

Maximum Dry Density 106.9 lb/ft^3
Optimum Moisture: 17.6%

3440 DISPLAY SCREEN

%PR 98.9

DD = 105.7
WD = 123.6

M = 17.9 %M = 16.9

PRACTICE PROBLEM 7

PROCTOR DATA

Maximum Dry Density 112.1 lb/ft^3
Optimum Moisture: 15.2%

3440 DISPLAY SCREEN

%PR 97.8

DD = 109.6
WD = 128.2

M = 18.6 %M = 17.0

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
REPORT OF NUCLEAR EMBANKMENT DENSITIES (UNIT MASSES)

English Metric

Report No.: 45 Date: Today Sheet No.: 1 of 1

Route No.: 252 County: Augusta

Project No.: 07-0252-132-101,C501

F.H.W.A. No.: None

Test For: Embankment

Nuclear Gauge Model No.: 3440 Serial No.: 23456

STANDARD COUNT

DENSITY	MOISTURE
2844	701

		Problem 5	Problem 6	Problem 7	
Test No.		1	2	3	
Location of Test	Station ft. (m)	305+00	305+60	306+20	
	Ref. to center line ft. (m)	@ C/L	10' Lt.	7' Lt.	
	Elevation	+10/-7	+3/-10	+3/-3	
Compacted Depth of Lift in. (mm)		6"	6"	6"	
Method of Compaction		Sheepsfoot	Sheepsfoot	Sheepsfoot	
A. Wet Density (lbs/ft^3), Wet Unit Mass (kg/m^3)	=				
B. Moisture Unit Mass (lbs/ft^3), Moisture Unit Mass (kg/m^3)	=				
C. Dry Density (lbs/ft^3), Dry Unit Mass (kg/m^3) (A - B)	=				
D. Moisture Content (B ÷ C) x 100	=				
E. Maximum Dry Density (lbs/ft^3), Dry Unit Mass (kg/m^3) Lab Proctor or One Point Proctor	=				
F. Percent Optimum Moisture From Lab or One Point Proctor	=				
G. Percent of plus #4, (plus 4.75mm)	=				
H. Corrected Maximum Dry Density (lbs/ft^3) Dry Unit Mass (kg/m^3)	=				
I. Corrected Optimum Moisture	=				
J. Percent Dry Density (lbs/ft^3), Dry Unit Mass (kg/m^3) (C ÷ E) x 100 or (C ÷ H) x 100	=				
K. Percent Minimum Density Required	=				

Remarks:

CC: District Materials Engineer
Project File

By: ____________________

Title: ____________________