WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
CONTRACT ADMINISTRATION DIVISION

MATERIALS PROCEDURE

NUCLEAR DENSITY TEST BY THE ROLLER PASS METHOD

1. PURPOSE

1.1 The purpose of this procedure is to determine the density of construction materials by the roller pass method. The procedure consists of two parts, with Part I to determine the required maximum density and Part II to compare field densities to the required maximum density.

2. SCOPE

2.1 This test method or method of testing is applicable to aggregate base courses, select material for backfilling, crushed aggregate backfill, granular subgrade, and random material having 40% or more of +3/4 inch (+19 mm) material as specified in MP 717.04.21.

3. REFERENCES

MP 712.21.26
MP 717.04.21

4. EQUIPMENT

4.1 One complete nuclear density gauge unit meeting the requirements specified in MP 717.04.21. This would include the manufacturer's printout of standard counts.

4.2 One measuring tape, approximately 50 feet (15 m)

4.3 Lime or other suitable material to mark test sites

4.4 Dry silica sand

4.5 Supply of data sheets

4.6 One vehicle meeting the safety and security requirements of the Nuclear Regulatory Commission for transporting nuclear gauges

5. PERSONNEL TRAINING

5.1 All personnel performing the testing must meet the minimum training requirements specified in MP 717.04.21.

5.2 All personnel must know and follow the requirements of the Nuclear Regulatory Commission.

6. ROUNDING OF DATA

6.1 Test values and calculations are to be rounded according to the following procedure:

6.1.1 If the figure following the last significant number to be retained is larger than five, increase the last significant number to be retained by one.

6.1.2 If the figure following the last significant number to be retained is five and there are no figures beyond five except zeros, the last significant number to be retained is increased by one if odd, or left unchanged if even.

6.1.3 If the figure following the last significant number to be retained is five and there are figures following the five, the last significant number to be retained is increased by one.

6.1.4 If the figure following the last significant number to be retained is less than five, the last significant number is left unchanged.

6.2 Test values and calculations shall be rounded to the following nearest significant digit:

6.2.1 Form T–313 (Test Section)

Lift thickness compacted	0.1 in. (10 mm)
Depth below grade	1 ft (0.1 m)
Length of test section	1 ft (1 m)
Width of test section	1 ft (0.1 m)
Station number	1 ft (0.1 m)
Offset	1 ft (0.1 m)
Dry density (DA)	1 lb ft^3 (1 kg/m^3)
Average density (DB)	1 lb /ft^3 (1 kg/m^3)
Maximum density (DC)	1 lb/ft^3 (1 kg/m^3)

6.2.2 Form T-317 (Quality Control Tests)

Station number	1 ft (0.1 m)
Offset	1 ft (0.1 m)
Depth below grade	1 ft (0.1 m)
Lift thickness compacted	0.1 in. (10 mm)
Maximum density (DC)	1 lb/ft^3 (1 kg/m^3)
Dry density (DE)	1 lb/ft^3 (1 kg/m^3)
Relative density (DF)	1%
Average DF ($\overline{X}$)	0.1%
Target (T)	1%
Quality index (QL)	0.01
Within tolerance (DG)	1%
Minimum percent for 100% Pay (DH)	1%

7. PREPARATION FOR TESTING

7.1 Standardization of the Nuclear Gauge

7.1.1 Warm up the gauge according to the manufacturer's recommendations.

7.1.2 Standardization of the gauge must be performed away from metal and other objects.

7.1.3 Clean the top of the standard block and the bottom of the gauge with a cloth.

7.1.4 Standardize according to manufacturer's recommendations.

7.1.5 Compare the standard counts to the manufacturer's standard counts using tolerances acceptable to the Division. For the Troxler 3430 gauge, the standard counts must be within ± 2% for density and ± 4% for moisture from the manufacturer's standards.

7.1.6 If the gauge is not within the specified tolerances for either moisture or density, repeat section 7.1.4 -7.1.5. If the gauge will not standardize for either moisture or density after 4 attempts, there is probably something wrong with the gauge. There may be electronics problems, the gauge needs calibrated or a stability check needs to be performed. Refer to MP 717.04.21 for a more detailed explanation. In any case, do not use a gauge for testing that will not standardize.

7.1.7 A gauge must be standardized before testing and at least every four hours during testing.

7.1.8 When a gauge is to be used for testing pipe or structure backfill in a trench, first check the standardization of the gauge according to sections 7.1 - 7.1.5. If the gauge is functioning properly, standardize the gauge in the trench. The standard counts in the trench would be used for testing in the trench only and the tolerances would not be applied to the standard counts taken in the trench. When the gauge is moved to a non-trench condition for testing, new standard counts would be required.

8. PART I PROCEDURE FOR DETERMINING THE MAXIMUM DENSITY

8.1 All data and calculations for Part I of this procedure will be recorded on form T-313 (copy attached). Record the project number, lab number etc. before starting the test.

8.2 The test is to be performed at the beginning of placement of an item. However, any problems with the material, placement or compaction equipment shall be corrected prior to performing the test.

8.3 The test section will be 100 feet (30 m) long by the width being placed in one operation except in restricted areas.

8.3.1 In restricted areas, where the 100 foot (30 m) length cannot be obtained, check the project's records to determine if a maximum density for the material has been determined on the project. The maximum density shall be used for Part II of this procedure, if available. A maximum density determined in a restricted area shall not be used in a non-restricted area. If a maximum density is not available for the material, obtain as large a test section as possible. For pipe backfill, a lift on both sides of the pipe can be used.

8.4 Divide the test section into 5 equal subsections and number the subsections. Randomly locate a test site within each of the subsections according to MP 712.21.26.

8.5 Water shall be added to untreated aggregates, if necessary, in a quantity satisfactory to the Engineer. The aggregate must visually appear wet in order to properly compact.

8.6 Once the material had been placed in the test section, the material shall be rolled with compaction equipment meeting the following requirements:

8.6.1 All compaction equipment must be in good working condition.

8.6.2 The materials shall be compacted with rollers providing a minimum applied force of 10 tons (9 Mg).

8.6.3 In restricted areas, inaccessible to conventional rollers, the compaction equipment must be satisfactory to the Engineer to provide the desired compactive effort. The Division may request verification that the above compaction equipment meets the specified requirements.

8.7 The test section shall be rolled with 12 roller passes. A roller pass is one complete coverage over the material. In restricted areas, where conventional rollers can not be used, the material shall be compacted until it appears well densified.

8.8 If the material shears or breaks down during rolling, the number of roller passes may need to be reduced. The designated number of roller passes must not be changed without the approval of the Engineer.

8.9 Once the material has been rolled, testing will be performed on test sites numbers 1 and 2.

8.10 Smooth the test site and fill any voids with fines scraped from the surface, no more than 1/8 inch (3 mm).

8.10.1 Place the guide plate on the test site. Next place the drive rod in the guide plate and while standing on the plate, drive the rod at least two inches (50 mm) deeper than the location where the end of the gauge source rod will be when testing. The gauge source rod can be extended in two inch (50 mm) increments. The source rod must be as deep as possible within the lift but must not extend beyond the lift. For example, a five inch (125 mm) lift would be tested with the source rod in the four inch (100 mm) position and the hole would be six (150 mm) inches deep. Carefully remove the drive rod to prevent material from falling into the hole.

8.10.2 Place the gauge over the test site and insert the source rod to the desired depth. Pull the gauge tight against the side of the hole toward the scaler. Make sure the gauge is sitting flush on the material. Mark the outline of the gauge with lime or other suitable material so the test sites can be relocated.

8.10.3 Take a one minute density reading.

8.10.3.1 Record the dry density (DA) in Section A of form T-313. Perform the same testing on site 2.

8.11 Average the two dry densities (DA) obtained in 8.10.3.1.

8.12 Roll the material in the test section two additional roller passes. In restricted areas, the compaction equipment would pass over the material the above indicated number of passes.

8.13 After the material has been rolled the additional number of passes, perform tests again on sites 1 and 2 according to 8.10 through 8.10.3 and record the values in section B.

8.14 Average the two densities according to 8.11.

8.15 Compare the value in 8.14 to the value obtained in 8.11. If the increase in density is 1 lb/ft^3 (16 kg/m^3) or less, the material is considered to have achieved its maximum density. If the increase in density is greater than 1 lb/ft^3 (16 kg/m^3), roll the material two additional passes according to 8.12 and repeat the testing on sites 1 and 2. Continue the rolling and testing sequence until the increase in density between two consecutive rolling sequences is 1 lb/ft^3 (16 kg/m^3) or less. The Division may request the contractor to cease rolling even though the increase is more than 1 lb/ft^3 (16 kg/m^3) if the material is breaking down.

8.16 Once the increase in density is 1 lb/ft^3 (16 kg/m^3) or less, move the last two density readings to the maximum density determination section on form T-313. Then take density measurements on sites 3, 4, and 5.

8.17 The average of the five density readings is the maximum density (DC) for the material.

8.17.1 The maximum density will be used to control the material for Part II of this procedure.

8.18 Division personnel may request that Part I be repeated if the test was not performed properly or the maximum density obtained does not appear to be realistic.

9. PART II QUALITY CONTROL TESTING

9.1 All test data and calculations for Part II of this procedure will be recorded on form T-317 (copy attached). Record the project number, item number, etc. on the form before starting the testing.

9.2 The lot number would have a prefix letter based on the following designations for the use of the material being tested:

Embankment	F
Subgrade	S
Base	B
Pipe and Structure Backfill	P

9.3 Transfer the maximum density (DC) and the lab number from form T-313 to form T-317. Record the lab number in the section for reference lab number.

9.4 Randomly locate the test site according to MP 712.21.26.

9.5 Determine the dry density (DE) with the nuclear gauge according to the procedure described in sections 8.10 through 8.10.3. The test sites do not have to be marked on the roadway.

9.6 Calculate the percent relative density (DF) by using the equation on form T-317.

9.7 Perform the remaining four tests in the lot. Five tests are always required to evaluate a lot.

9.8 Calculate the average relative density ($\overline{X}$) for the five tests in the lot.

9.9 Obtain the target percentage of dry density (T) from the project's governing specifications.

9.10 Determine the range (R) of the relative densities (DF) by subtracting the smallest value from the largest.

9.11 Calculate the quality index (QL) by using the equation on form T-317.

9.12 Use the Table for Estimating the Percent of a Lot Within Tolerance (copy attached) and determine the percent within tolerance (DG) that corresponds to the QL value calculated in 9.11 above.

9.13 Obtain the minimum percent for 100% pay (DH) from the project's governing specifications.

9.14 In order for a lot to meet specifications, the percent within tolerance (DG) must be equal to or greater than the minimum percent for 100% pay (DH).

10. General

10.1 Independent tests for similarity checks can be recorded on form T-317. Use only the applicable sections of the form.

10.2.1 If the material changes or the material is supplied from a new source, repeat Part I to obtain new control data.

10.3 If the percent relative densities are consistently above 105 percent or below 95 percent, and there is no apparent cause for the high or low values, repeat Part I to obtain new control data.

10.4 Test data for several lots can be recorded on form T-317.

Aaron C. Gillispie

Aaron C. Gillispie, P.E.
Director
Materials Control, Soils
And Testing Division

ACG:Lw

Attachments

ATTACHMENT NO. 1

TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE

Quality Index (QL) Positive Values	Percent Within Tolerance
.66	99
.65	98
.62	97
.60	96
.58	95
.57	94
.55	93
.53	92
.51	91
.50	90
.48	89
.46	88
.45	87
.44	86
.42	85
.41	84
.40	83
.38	82
.37	81
.36	80
.34	79
.33	78
.32	77
.30	76
.29	75
.28	74
.27	73
.25	72
.24	71
.23	70
.22	69
.21	68
.19	67
.18	66
.17	65
.16	64
.15	63
.14	62
.13	61
.11	60
.10	59
.09	58
.08	57
.07	56
.06	55
.05	54
.04	53
.02	52
.01	51
.00	50

Quality Index (QL) Negative Values	Percent Within Tolerance
.00	50
.01	49
.02	48
.04	47
.05	46
.06	45
.07	44
.08	43
.09	42
.10	41
.11	40
.13	39
.14	38
.15	37
.16	36
.17	35
.18	34
.19	33
.21	32
.22	31
.23	30
.24	29
.25	28
.27	27
.28	26
.29	25
.30	24
.32	23
.33	22
.34	21
.36	20
.37	19
.38	18
.40	17
.41	16
.42	15
.44	14
.45	13
.46	12
.48	11
.50	10
.51	9
.53	8
.55	7
.57	6
.58	5
.60	4
.62	3
.63	2
.66	1

West Virginia Division of Highways
Materials Control Soil and Testing Division

Lab Number _____
Auth. Number _____
Project Number _____
District Number _____
Item Number _____
Date _____

FORM T-313
MP 700.00.24
REV. 08-08

Source of Material:			Length of Test Section:	
Roller Type:			Width of Test Section:	
Roller Weight	Static:	Working:	Gauge Number	
Lift Thickness Compacted:			Manufacturer's Standards	
Depth Below Grade:			Density:	Moisture:
Depth of Gauge Source:			Standard Counts	
Observed	Yes	No	Density:	Moisture:

Test Site Number	1	2	3	4	5
Station Number					
Offset					

A	Number of Passes	
	Test Site	DA	Dry Density
	1	
	2	
DB	Average	

B	Number of Passes	
	Test Site	DA	Dry Density
	1	
	2	
DB	Average	

C	Number of Passes	
	Test Site	DA	Dry Density
	1	
	2	
DB	Average	

D	Number of Passes	
	Test Site	DA	Dry Density
	1	
	2	
DB	Average	

DB = $\sum$ DA / 2

DC = $\sum$ DA / 5

Maximum Denisty Determination		
Test Site	DA	Dry Density
1		
2		
3		
4		
5		
DC	Max. Density	

Inspector's Name: _____
Inspector's Signature: _____
Project's Evaluation
Checked By: _____
Date: _____

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS & TESTING DIVISION

LAB NUMBER _____
AUTH. NUMBER _____
PROJECT NUMBER _____
DISTRICT _____
ITEM NUMBER _____

FORM T-317
MP 700.00.24
REV. 08-08

GAUGE #	DATE					
MANUFACTURER'S DENSITY STANDARD	LOT NUMBER					
	BEGINNING STATION					
	ENDING STATION					
MANUFACTURER'S MOISTURE STANDARD	OFFSET					
	DEPTH BELOW GRADE					
	DEPTH OF GAUGE SOURCE					
	LIFT THICKNESS COMPACTED					
DC FROM TEST SECTION	DENSITY STANDARD					
	MOISTURE STANDARD					

$$DF = \frac{DE\ (100)}{DC}$$

$$\overline{X} = \frac{\Sigma\ DF}{5}$$

$$QL = \frac{\overline{X} - T}{R}$$

	DC	**MAXIMUM DENSITY**					
		REFERENCE LAB NUMBER					
TEST NUMBER 1	DE	DRY DENSITY					
	DF	% RELATIVE DENSITY					
TEST NUMBER 2	DE	DRY DENSITY					
	DF	% RELATIVE DENSITY					
TEST NUMBER 3	DE	DRY DENSITY					
	DF	% RELATIVE DENSITY					
TEST NUMBER 4	DE	DRY DENSITY					
	DF	% RELATIVE DENSITY					
TEST NUMBER 5	DE	DRY DENSITY					
	DF	% RELATIVE DENSITY					
LOT EVALUATION	$\overline{X}$	AVERAGE DF					
	T	TARGET					
	QL	QUALITY INDEX					
	DG	% WITHIN TOLERANCE					
	DH	MIN. FOR 100% PAY					
	DI	PASS / FAIL					

INSPECTOR'S NAME: _____
INSPECTOR'S SIGNATURE: _____

PROJECT'S EVALUATION

CHECKED BY: _____ DATE: _____