Determination of In-place Density of Soils and Aggregates by Nuclear Method

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1. Scope:

This test is for determining density of soil and aggregate, including lime treated material, by the nuclear method.

2. Apparatus:

2.1 Nuclear moisture-density gauge capable of determining densities by the direct transmission method and conforming to the requirements of AASHTO T 310.

2.2 A reference standard block for taking standard counts.

2.3 A drill rod, extraction tool, and combination guide-scraper plate for preparing the test site and punching the hole for the source rod.

2.4 A manufacturer's instruction manual for the nuclear gauge.

2.5 A nuclear gauge information book, transportation documents book, and nuclear badge.

2.6 A hammer to drive the drill rod, and a shovel and other tools for site preparation.

3. Procedure:

3.1 Calibration.

A. The Central Laboratory shall calibrate nuclear gauges annually and each time repairs are made.

3.2 Standard counts.

A. Turn the gauge on and allow the gauge to warm up for at least 10 minutes.

B. Place the gauge on the reference standard block and take the standard count as recommended by the manufacturer.

C. Take at least one 4 minute standard count daily. This count should compare within 1% of the average of the 4 previous standard density counts and compare within 2% of the average of the 4 previous standard moisture counts for the gauge. If the standard count varies by more than these tolerances, do not accept the standard count. Check that all the manufacturer's guidelines have been followed and take another standard count.

NOTE: If the second count also fails, follow the manufacturer's recommendation for the particular model gauge for taking and recording 4 additional standard counts.

D. Record the results of the standard count in the gauge's logbook and on form DOT-41.

3.3 Site preparation.

A. Select a location for the test where the gauge will be at least 2' away from any vertical projection, at least 10' away from any vehicle and at least 30' away from another nuclear gauge.

B. Remove material, as necessary, to reach the top of the compacted lift to be tested. Prepare a horizontal area, sufficient in size to accommodate the gauge, using the scraper plate supplied with the gauge, by planing to a smooth condition to obtain maximum contact between the gauge and the material being tested. Make sure the gauge sits solidly on the site without rocking.

C. The maximum depressions beneath the gauge shall not exceed 1/8". Use native fines or fine sand to fill voids and level the excess with the scraper plate. The total areas thus filled with fines or sand should not exceed 10% of the bottom area of the gauge.

3.4 Wet density determination.

A. Place the guide-scraper plate on the prepared test site and drive the drill rod with the extraction tool attached through the guide to a depth at least 2" below the depth of the material to be measured. Remove the drill rod by pulling it straight up and twisting the extraction tool, to avoid disturbing the hole.

B. Place the nuclear gauge over the test site and extend the source rod into the hole to the desired depth. Release the trigger at the desired depth and listen for the "Click" indicating that the source rod is properly locked into position on the index rod. Verify the depth shown on the display of the gauge agrees with the actual depth of the source rod. Slide the gauge so the surface of the source rod nearest the keypad is in contact with the edge of the hole.

Take a one-minute reading to determine the wet density in lbs./ft^3 and record this number on the DOT-41 worksheet. It is recommended that you take more than one reading and average the results. At the completion of wet density measurements, dig up the area beneath the gauge to collect the moisture specimen and visually check for large voids or inconsistent material which may give inaccurate results. If a large void or inconsistent material is encountered, disregard the test and move to a nearby location. The moisture content used to

determine the in place dry density must be collected from beneath the gauge.

3.5 Correction determination.

A. At least five tests must be performed using the nuclear gauge on mechanically compacted material and compared against SD 105 or SD 106 to compute a wet density correction (Figure 2) Use the DOT-39 to calculate the wet density correction. If an individual comparison is determined which is not within 3.0 lbs./ft^3 of the Correction (Running average) calculated from the previous five individual comparisons, the results shall be considered suspect and additional checks should be run to determine if the material has changed.

After the wet density correction is determined, it is applied to future tests performed with the nuclear gauge. Each type of material shall have a different correction. Embankment material shall have a correction determination separate from surfacing material. Corrections are not interchangeable between nuclear gauges, and must be individually determined. If a change in project, change in material source, unusually high or low density readings, considerable changes in sieve analysis, or visual change in material, additional checks should be completed and documented on a DOT-39.

NOTE: The nuclear gauge moisture reading shall never be used for determination of in-place dry density.

B. Additional comparison checks against SD 105 or SD 106. These tests shall be performed at a minimum of at least once per 20 wet density tests. Results shall be documented on the DOT-39 worksheet and the Correction (Running average) reevaluated for the five most recent wet density comparison tests performed. Results from Independent assurance tests may be used in determining the correction.

C. If a discrepancy exists, contact the Region Materials Engineer.

3.6 Standard density determination.

A. To determine standard density, take material from or adjacent to the test hole for SD 104, method 2 or method 4.

4. Report:

4.1 Calculations of wet density correction on DOT 39

A = Balloon or sand cone density in lb/ft^3.

B = Wet density in lbs./ft^3 determined by the nuclear gauge.

C = A – B

D = Correction (Running average) of 5 most recent values of C in lb/ft^3.

Wet Density = Nuclear wet density + correction

4.2 Report the percent of standard density to the nearest whole percentage point.

5. References:

AASHTO T 310
SD 105
SD 106
SD 108
DOT-39
DOT-41

Sample ID 2205215 **Density Report** **DOT - 41**

File No. **9-16**

County Aurora, Ziebach PCN/PROJECT B015 PH 0066(00)15

Station 28+91 Dist. From CL 17' R Width (Gravel)

Depth (from top of Subgrade or Pipe) (Hole - Gravel) Field # E055

Tested By Tester (TEST), One Checked By Tester (TEST), Two Date 04/28/2015

WORK AREA REPRESENTED (Circle what applies)

EMBANKMENT STA. TO STA. 26+00 to 52+00 (per half mile, for each roadbed)

Zone 1(0-1ft.) Zone 2(1-3 ft.) Zone 3(3-5 ft.) Zone 4(5 ft. to base, 1 per 5 ft.)

BRIDGE END EMBANKMENT STA. TO STA.

1 per zone within plan limits 3 equal zones when backwall is less than 7 ft. 4 equal zones when backwall is 7 ft. or greater

Zone 1 Zone 2 Zone 3 Zone 4

BERM STA. TO STA. (100 ft. from Bridge End)

Zone 1(0-1ft.) Zone 2(1-3 ft.) Zone 3(3-5 ft.) Zone 4(5 ft. to base, 1 per 5 ft.)

PIPE

CROSS	24" or Smaller	undercut	(1/2 way up)	(0-2 ft. Above)		
STORM	30" to 72"	undercut	(Lower 1/2)	(Upper 1/2)	(0-2 ft. Above)	
INTERSECTION	72" or more	undercut	(Bottom 1/3)	(Middle 1/3)	(Top 1/3)	(0-2 ft. Above)

After Minimum for size pipe installation ☐ 1 per 3 ft. of backfill beginning at 2' above top of pipe

SUBBASE STA. TO STA. LIFT

BASE COURSE STA. TO STA. LIFT

Curve Used	Standard Density Maximum Density	Optimum Moisture		Granular Material 4-Point Range		
0	U. 107.1	18.1	%	-	SPECIFICATION 95 %	% Obtained 100 X (G/U) 98 %

Balloon Method

B. Wt. Undried Matl. from Hole	
C. Volumeter Reading in Hole	
D. Initial Volumeter Reading	
E. Volume of Test Hole (C - D)	
F. Wet Density (B / E)	
G. Dry Density F / (100 + M) x 100	

Sand Density

A. Std. Sand PCF		
B. Wt. Undried Matl. from Hole		
C. Initial Wt. Sand		
D. Final Wt. Sand Plus Cone Sand		
E. Volume of Test Hole (C - D) / A		
F. Wet Density (B / E)		
G. Dry Density F / (100 + M) x 100		

Nuclear Method

Meter No. MQ 778

Test Mode 6" DIRECT TRANSMISSION

A. Wet Density from Gauge 120.80

± Corr. * 1.20 = 122.0

B. Dry Density 105.4

A / (100 + M-Field) x 100

16

1-Point Density Determination

		1-Point	Field
O. Weight of Mold & Specimen	13.32	130.7	109.1
P. Weight of Mold	9.23	112.5	94.3
Q. Wet Wt. of Molded Specimen (O- P)	4.09	18.2	14.8
R. Factor of Mold No. P-1885 Used in Test	30.01		
S. Wet Density (Q x R)	122.7	112.5	94.3
T. Dry Density S / (100 + M [1-PT]) x 100	105.6	16.2	15.7

Moisture Determinations

H. Wt. of Wet Matl. and Container	
I. Wt. of Dry Matl. and Container	
J. Wt. of Moisture (H - I)	
K. Wt. of Container	
L. Wt. of Dry Matl. (I - K)	
M. Percent Moisture Field (J x 100) / L	

Rock Determination

A. Total Sample Weight	
B. Weight of Material Retained on 3/4" Sieve	
C. Percent Retained On 3/4" Sieve (B x 100)/A	

* Correction from DOT-39. If there is no correction or, if the correction has been applied to the meter show "NA".

Figure 1

Sample ID 2205230
File No.

Determination of Corrections for Moisture and Density by the Nuclear Method

DOT - 39
9-14

INFO.

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
Tested By Tester, One Checked By Tester, Two Test Date 04/28/2015
Nuclear Gauge Number MQ 778 Material Type Unclassified Excavation

MOISTURE (PERCENT)

Test No.	Date	Oven Dry	Nuclear Gauge	Individual Comparison Oven Dry - Nuclear	Correction (Running Avg.)
E001	06/03/2015	26.7	25.1	1.6	
E002	06/03/2015	23.9	22.1	1.8	
E003	06/03/2015	26.2	25.2	1.0	
E004	06/04/2015	12.4	10.9	1.5	
P002	06/04/2015	12.7	11.4	1.3	1.4
E025	06/08/2015	19.5	19.7	-0.2	1.1
E045	06/18/2015	18.3	16.8	1.5	1.0
E065	06/22/2015	18.7	17.5	1.2	1.1
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	00/00/0000	.	.		
	00/00/0000	.	.		
	00/00/0000	.	.		
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	00/00/0000	.	.		
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ACTUAL MOISTURE = NUCLEAR MOISTURE + CORRECTION (RUNNING AVG.)

WET DENSITY (LBS/CUFT)

Test No.	Date	Sand or Balloon Test	Nuclear Gauge	Individual Comparison Balloon/Sand - Nuclear	Correction (Running Avg.)
E001	06/03/2015	123.2	122.7	0.5	
E002	06/03/2015	122.4	121.3	1.1	
E003	06/03/2015	122.8	121.8	1.0	
E004	06/04/2015	126.2	123.5	2.7	
P002	06/04/2015	127.8	127.6	0.2	1.1
E025	06/08/2015	124.5	122.2	2.3	1.5
E045	06/18/2015	127.1	126.3	0.8	1.4
E065	06/22/2015	126.1	126.2	-0.1	1.2
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	00/00/0000	.	.		
	00/00/0000	.	.		
	00/00/0000	.	.		
	00/00/0000	.	.		
	00/00/0000	.	.		
	00/00/0000	.	.		

ACTUAL WET DENSITY = NUCLEAR DENSITY + CORRECTION (RUNNING AVG.)

CC: Region Materials Engineer

Figure 2