Recommend Approval: Team Leader 03/05/12 Date Division Chief 03/05/2012 Date Approved: Director 03/14/12 Date	Maryland Department of Transportation State Highway Administration Office of Materials Technology MARYLAND STANDARD METHOD OF TESTS	
	IN-PLACE DENSITY OF EMBANKMENT, SUBBASE, BASE, SURFACE, AND SHOULDER MATERIALS USING THE NUCLEAR D/M GAUGE	**MSMT 352**

SCOPE:

These procedures are used to determine the in-place density of embankments, subbase, bases, surface, and shoulder materials using the Troxler Nuclear D/M gauge Model Nos. 3411-B, 3440, or equivalent.

REFERENCES:

T 2

T 239

MSMT 350

MSMT 351

MATERIALS AND EQUIPMENT:

1. Troxler Nuclear D/M gauge Model Nos. 3411-B, 3440 or equivalent.
2. Lab Form - SHA 73.0-161.
3. Site preparation "scraper" plate.
4. Reference standard.
5. Hole driving rod and extraction tool.
6. Sledgehammer.
7. Manufacturer's instruction manual.
8. Optimum Moisture/Maximum Dry Density values (soils chart) as determined by MSMT 351.

OPERATORS QUALIFICATION

All qualified State or Contractual personnel on State Highway Administration (SHA) projects shall carry an identification card to show successful completion of the required training; which includes annual safety training in conformance with the MDOT-SHA licensing agreement with Maryland Department of the Environment, Radiological Health Program.

STANDARDIZATION OF EQUIPMENT

Standardization of equipment on a reference standard is required at the start of each day's use, and when test measurements are suspected not to conform to proper measurements as determined by MSMT 350.

1. Warm up the equipment in conformance with the manufacturer's recommendations.

2. Place the unit in the reference standard in conformance with the manufacturer's instructions ("Keypad" end against butt plate on standard block).

3. Remove the lock from the trigger and make certain the handle is indexed in the safe position.

4. Keep all other radioactive sources at least 30 ft away from the gauge to avoid affecting the standard count.

5. Gauge Standardization:

    a) **Model 3411-B**: Set the function switch to slow with the gauge on the reference standard and depress the shift and standard keys. After four minutes, the density and moisture standard counts can be displayed by depressing the DS and MS keys, respectively. This constitutes one standardization check for density and moisture readings, (if DS and MS show "0000", repeat the standard count). Compare counts to existing average of four previous counts, or continue taking counts until average of four is established.

    b) **Model 3440**: Set gauge on the reference block, turn gauge on, and allow gauge to complete RAM and self test. Press standard and follow series of questions. After standard count is completed, gauge will tell you "P" (pass) or "F" (fail).

6. If the standard counts are outside the limits set, repeat the standardization check. Maximum deviations of ±1 percent are permitted for density standardization, and ±2 percent for moisture standardization. If the second standardization check is within limits, then the equipment is considered to be in satisfactory operational condition. If however, the second standardization check is not within the limits, then the equipment is considered inoperable. Suspected instability is checked by determining a minimum of four standardizations in the field. If the highest and

lowest counts differ by more than 25 counts for density or 12 counts for moisture, contact your area Radiation Safety Officer.

NOTE: Model 3440 will retain the last standard count in memory, even when off. The 3411-B will erase the standard count when turned off.

MAXIMUM DRY DENSITY (MDD)

Gauge Set-Up:

The compaction percentage is obtained by using either Nuclear D/M Gauge Method A or B and the maximum dry density result from MSMT 351. Use Method A (Direct Transmission), if possible. Use Method B (Backscatter) if the following conditions exist:

a) Where disturbance of the material by drilling might alter the in-place density, or

b) Where the material is too hard for the drill rod to penetrate to the desired depth.

With the gauge turned on, warmed up, and standardized, enter the maximum dry density value obtained from the Typical Curve Chart into either model:

a) **Model 3411-B**: Enter the maximum dry density of the material to be tested ("Lab Value") by depressing SHIFT and SET and holding SET down (with the ± knob set to increase or decrease the factory setting of 124.8 to the appropriate value). Holding SET continuously will advance the setting rapidly, while individual touches to SET will advance the setting by 1/10 increments. If the desired value is overrun, you may change the ± knob and return to the correct value without restarting this function. This value will <u>not</u> be retained in memory when gauge is turned off.

b) **Model 3440**: Depress the Proctor key, select #2 and follow instructions on LCD.

Both models are designed to display the following data:

a) in-place wet density lb/ft^3,

b) weight of water lb/ft^3,

c) in-place dry density lb/ft^3,

d) percent water of dry weight of material (moisture content), and percent compaction of in-place material as compared to the MDD value provided by the Laboratory or obtained by field performance of MSMT 351.

<u>TEST PROCEDURES:</u>

METHOD A - DIRECT TRANSMISSION - MOISTURE AND DENSITY

1. Select a test location where the gauge in its test position will be at least 2 ft away from any vertical structure or trench wall. Trench corrections are not necessary for direct transmission densities; however, since all moisture readings are taken in the Backscatter mode, moisture trench corrections are usually needed when tests are made near structures or trench walls. (refer to Method C-Trench Correction)

2. Prepare the test site in the following manner:

    a) Remove all loose and disturbed material as necessary to expose the top of the material to be tested.

    b) Prepare a horizontal area sufficient in size to accommodate the gauge. Using the scraper plate, plane the area to a smooth condition to obtain maximum contact between the gauge base and the material being tested.

    c) The placement of the gauge on the surface of the material to be tested is critical to the successful determination of density. The optimum condition is full contact between the bottom surface of the gauge and the surface of the material being tested. If this is not possible, then correct the surface irregularities by the use of native fines as filler. The depth of filler shall not exceed 1/8 in. and the total area filled shall not exceed 10 percent of the bottom area of the gauge. Several trial seatings may be required to achieve these conditions.

3. Make a hole in the prepared surface using the guide and the hole driving rod. The hole shall be of such depth and alignment that insertion of the probe will not cause the gauge to tilt from the plane of the prepared area. The test hole shall be 2 in. deeper than the intended depth of test.

4. Proceed with the test in the following manner:

    a) Tilt the gauge and extend a small portion of the source rod to align the probe with the hole.

    b) Seat gauge firmly on the prepared surface.

    c) Insert the probe in the hole to the desired depth.

    d) Pull the gauge gently in the direction of the keypad until the probe makes firm contact with the side of the hole.
    e) Keep all other radioactive sources at least 30 ft away from the gauge to avoid affecting the measurement.

f) **Model 3411-B**: The depth switch shall be set to equal the depth of the source rod, and moisture correction on +00. Take one, one minute reading with the function switch in the normal mode. At the end of the one minute time period, moisture and density measured counts can be displayed by depressing MC and DC, respectively. Depress WD and the value of the wet density will appear. Depress DD and the value of the dry density will appear. Repeat for weight of water (M), and percent moisture (%M). Press shift and %PRO for percent compaction.

g) **Model 3440**: Place source rod at desired depth. The gauge will automatically adjust. Take a one minute reading, at the end of which the LCD screen will display WD, DD, M, and %PRO. Press Shift and Recall to display MC and DC.

METHOD B - BACKSCATTER-MOISTURE AND DENSITY

1. Repeat steps 1 & 2 as shown in Method A. If the test site is located near a vertical structure or trench wall, refer to Method C - Trench Correction.

2. Proceed with the test in the following manner:

   a) Seat the gauge firmly.

   b) Keep all other radioactive sources at least 30 ft away from the gauge to avoid affecting the measurement.

   c) **Model 3411-B**: Set the depth switch to BS, the PWR/Time knob to norm, and Moisture Correction knobs to zero. Place the source in the Backscatter position (1st notch) and take a one minute reading. At the end of the normal one minute time period, moisture and density measured counts can be displayed by depressing MC and DC, respectively. Depress WD and the value of the wet density will appear. Depress DD and the value of dry density will appear. Repeat for weight of water, M and percent moisture, (%M). Depress SHIFT and %PRO for percent compaction.

   d) **Model 3440**: Place source rod in Backscatter position from which the gauge will automatically adjust. Take a one minute reading, at the end of which the LCD screen will display WD, DD, M, %M, and %PRO. Press Shift and Recall to display MC and DC.

METHOD C TRENCH CORRECTION

1. Often, when nuclear densities are performed on backfill in trenches, the dry density is suspect. The usual cause is additional moisture from the structure or the trench wall.

2. A trench correction factor may be needed when performing tests within 2 ft of a trench wall, bridge abutment, retaining wall, or other vertical structure. This is obtained by subtracting the standard moisture count from the trench moisture count (follow gauge manufacturers instructions).

3. The trench test should be taken at approximately the same distance from the trench wall with the gauge in the same position as the measurement made for the trench moisture count.

CALCULATIONS:

The following calculations are not necessary when operating a Troxler Moisture-Density surface nuclear gauge Model No. 3411-B or 3440. This direct readout instrument performs all the calculations and displays them when the proper keys are depressed.

As a check of the Nuclear D/M Gauge or by hand without the use of the gauge, use the following calculations:

1. Calculate the dry density of the soil by subtracting the moisture in lb/ft^3 from the wet density in lb/ft^3 (S.H.A. 73.0-161, Line 13).

2. Calculate the moisture content in percent of dry weight of soil as follows:

$$M = (W_m/W_d) \times 100 \text{ (S.H.A. 73.0-161, Line 10)}$$

where:

M = moisture content,

W_m = moisture of soil, lb/ft^3, and

W_d = dry weight of soil, lb/ft^3.

3. Calculate the percent compaction of the material as follows:

$$C = \frac{D_d}{D_m} \times 100 \text{ (S.H.A. 73.0-161 Line 18)}$$

where:

C = percent compaction obtained,

D_d = in-place dry density, lb/ft^3, and

D_m = maximum dry density from Typical Curve Chart, lb/ft^3.

REPORT:

Reports for in-place density test results shall consist of the appropriate form (SHA 73.0-161) for a specific material. Record all pertinent data on this form including the date, exact location of the density hole, and characteristics of the material being tested. Results and data obtained during the test will form part of the report. Report all percentages to the nearest whole percent.

MSMT 352
Rev. 9/97

MARYLAND STATE HIGHWAY ADMINISTRATION
NUCLEAR D/M COMPACTION REPORT

S.H.A. 73.0-161

Gauge Model:_____ Gauge Serial No.:

Contract No.:_____ F.A.P. No.: _____ Date:

Operator:_____ Standard Count: Moisture MS: _____ Density DS:

_____ Density DS:

Average of four previous counts: Moisture MS:

TEST SITE DATA	1. FIELD TEST NUMBER								
	2. TYPE MATERIAL & C.Y. THIS FILL								
	3. SOURCE								
	4. STATION								
	5. ITEM NO.								
	6. DISTANCE TO CENTER LINE or BASE LINE								
	7. HEIGHT TO FINAL GRADE								
MOIST & DENSITY	8. MEASURED COUNT, MC								
	9. Weight OF MOISTURE, M, P.C.F.								
	10. MOISTURE CONTENT, % M (NOTES 1,2)								
	11. MOISTURE CORRECTION (NOTE 2)								
	12. MEASURED COUNT, DC								
	13. WET Weight, WD, P.C.F.								
	14. DRY Weight, DD, P.C.F.								
COMPACTION	15. MAXIMUM DRY DENSITY FROM CHART								
	16. OPTIMUM MOISTURE FROM CHART, % (NOTE 3)								
	17. COMPACTION REQUIRED, % (NOTE 3)								
	18. COMPACTION OBTAINED, % (NOTE 4)								

SIEVE DATA	19. FIELD TEST NUMBER								
	20. COLOR (primary followed by secondary, if any)								
	21. SOIL DESCRIPTION (i.e. texture, such as sandy clay w/gravel or clayey silt w/mica)								
WET DENSITY	22. PERCENT PASSING # 4 SCREEN (if < 65% use MSMT 351 method D)								
	23. Weight OF MOLD & WET SOIL,LBS.								
	24. Weight OF MOLD, LBS.								
	25. Weight OF WET SOIL(#23-#24), LBS								
	26. WET DENSITY OF SOIL IN MOLD (#25 x 30), P.C.F.								
	26A. MAX DRY DENSITY FROM CHART, P.C.F.								
	26B. OPTIMUM MOISTURE FROM CHART, %								
MOISTURE	27. Weight OF WET SOIL & TARE, LBS								
	28. Weight OF DRY SOIL & TARE, LBS								
	29. Weight OF TARE, LBS.								
	30. Weight OF DRY SOIL(#28-#29), LBS.								
	31. Weight OF MOISTURE(#27-#28), LBS.								
	32. MOISTURE, % (#31/#30) x 100								

NOTES

Note: 1. % moisture should not vary more than ± 2% between 2 tests on same grade taken within same 4 hour shift. If % moisture varies, it indicates possible changes in material.

Note: 2. % of moisture should not exceed true moisture by more than 2%. If it does, then moisture correction is required.

Note: 3. MDD & Opt. moisture are obtained from typical curve or family of curves for source material per line #3, and verified by plotting results of MSMT 351 from line #26 and against the typical curve or by plotting against the result of a field five-step moisture-density determination for materials not previously identified.

Note: 4. Refer to Contract Specs or Md Standard Spec. to obtain % compaction required for type material recorded on line #2.