METRIC/ENGLISH

Method of Test for
THE DETERMINATION OF IN-PLACE DENSITY
DOTD Designation: TR 401

INTRODUCTION

The method of determining in-place densities shall be selected by the engineer. Although all methods (devices) specified are considered acceptable for determining in-place density and percent density for soils, aggregates and soil-aggregate mixtures, untreated, treated or stabilized, the nuclear device is hereby designated as the department's official standard for in-place density.

When using a nuclear device to conduct in-place density tests, the method corresponding to the device model number shall be used. Densities determined with the nuclear density device will normally be the average of three individual test results. However, when testing in a trench within six feet of a wall, due to the small mass of material being tested, only one test will be required. For other tests, density will be the average of three tests taken at intervals of approximately 120° around the same access hole. This method of testing is consistent with the recommendations of the manufacturer of these devices. When the sand cone is used, only one test location is required.

Table of Methods

Method A -	Nuclear Device – Troxler Model 3440
Method B -	Nuclear Device – Troxler Model 3411
Method C -	Nuclear Device – Humboldt Model HS-5001 EZ

Only an Authorized Nuclear Device Operator (operator) is to operate a nuclear device. Completion of training and the holding of a valid nuclear film badge and an operator's license issued by the Materials and Testing Section is required for authorization. This film badge is to be worn at all times when transporting, handling, or operating a nuclear device. Although there is no danger of overexposure to radiation from normal use of this equipment, improper handling, transport or operation may lead to radiation hazards. The operator's license is also to be carried at all times when an operator is transporting, handling, or operating a nuclear device.

All applicable safety precautions, outlined in the manufacturer's operations manual for the nuclear device, shall be followed. When required, cleaning of the source rod in the field will be accomplished by wiping the rod with a cloth held by a remote device, such as long tongs. Any nuclear device requiring more extensive cleaning or repairs shall be transported to the District Laboratory.

Each nuclear device, regardless of ownership, used for acceptance testing on a DOTD project shall be approved by the Materials and Testing Section prior to use and every two years thereafter. This approval includes the evaluation of calibration checks and leak tests. Leak tests are to be performed every six months. A log with the device model and department assigned number shall be kept with each device listing all moisture and density standard counts.

When asphalt cement or other asphaltic materials are present and a nuclear device is used to determine in-place density, the moisture content used to determine the dry density shall be obtained by either stove or oven drying, in accordance with DOTD TR 403. When discrepancy occurs between a

moisture content obtained with a nuclear device and a moisture content obtained in accordance with DOTD TR 403, the moisture content obtained in accordance with DOTD TR 403 shall be utilized to determine in-place density.

It will be necessary to perform moisture correction procedures on some materials, because they contain hydrogen in a form other than water. The nuclear device detects this hydrogen and computes it as water, yielding a moisture content higher than actual moisture. In most soils which occur naturally in Louisiana, this problem will not occur. However, soils or soil aggregate mixtures which contain reclaimed asphaltic concrete, recycled portland cement concrete, cement, lime, fly ash, coal, mica bearing clays, gypsum (calcium sulfates), phosphates or organic matter may cause erroneous moisture readings. Boron and cadmium will also cause the nuclear device to yield a lower than actual moisture content. Soils or soil-aggregate mixtures containing these materials will require the determination of their actual moisture content in accordance with DOTD TR 403. When a nuclear device operator encounters results which are obviously outside the normal pattern, moisture content determinations shall be performed to identify if an erroneous moisture reading is the cause of the unusual test results. When such a situation occurs, contact the District Laboratory Engineer.

THE DETERMINATION OF IN-PLACE DENSITY
DOTD Designation: TR 401
Method A – Troxler Model 3440

I. Scope

A. This method of test is designed to determine the in-place density of soils, aggregates, or soil-aggregate mixtures, untreated, treated or stabilized, using the Troxler Model 3440 nuclear device.

B. Reference Documents
   1. DOTD TR 403 – Determination of Moisture Content
   2. DOTD TR 415 – Field Moisture – Density Relationships
   3. DOTD TR 418 – Moisture – Density Relationships

II. Apparatus

A. Approved Troxler Model 3440 nuclear device – with locks and keys
B. Operator's manual – for nuclear device
C. Transport case – for nuclear device, **with locks and keys**
D. Reference standard block
E. Scraper plate/drill rod guide
F. 19 mm (¾-inch) drill rod or 19 mm (¾-inch) auger.
G. Extraction tool (optional)
H. Standard Count Log
I. Operator's nuclear film badge and operator's license
J. Dry fine sand
K. Hand tools – 2 – 3 kg (4 – 6 lb) maul, shovel, straightedge
L. Worksheet – Density and Moisture Content, DOTD Form No. 03-22-0750 (Figure A-1 front and back)

III. Standardization

A. Procedure
   1. Turn the device on by pressing the **ON** key. The device will automatically go through a self-test routine for five minutes.

Note A-1: *Do not turn the device off while the self-test display is on. Turning the device off while the self-test display is on may result in the loss of device memory.*

   2. Clean the top of the reference standard block, being sure that there is no soil or other material which would prevent a good seat between the device and the block.
   3. With the probe retracted, clean the base of the device, being sure that there is no soil or other material which would prevent a good seat between the device and the block.
   4. Place the reference standard block on the compacted material with a minimum density of 1600 kg/m^3 (100 lb/ft^3), at least 2 m (6 ft) from any large object and at least 10 m (30 ft) from any other nuclear device. When a test is to be performed in an area with less than a 2 m (6 ft) clearance from an object (e.g., near a wall, pipe, vehicle, or in a trench), the trench offset factor, as determined in Step III.C should be utilized at the

exact location as the test counts in lieu of standard counts, and shall not be entered in the Standard Count Log.

5. Place the device on the reference standard block with the source in **SAFE** position, making sure there is a good seat between the device and the block.
6. Press the **STANDARD** key to obtain the first display. The display will show the standard counts, and a question, similar to the following example.

   Standard Count
   MS = 640
   DS = 3560
   Take a new count?

7. Press the **YES** key to take a new count and obtain the second display. The display will show a question similar to the following example.

   Is gauge on Std.
   block and source
   rod in SAFE pos?

8. If the device is on the standard block and the source rod in the SAFE position, press the YES key. A third display will appear similar to the following example.

   Taking
   Standard Count
   240 seconds
   remaining

9. When the standard count is completed, the device will beep and display the results of a four-minute standard count, similar to the following example.

   MS = 660 0.3%P
   DS = 3540 01%P
   Do you want to
   use the new STD?

Note A-2: *The **P** to the right of the percentage figures indicate that the new counts are within the 1% density and 2% moisture limits. If the percentages are not within these limits, an F will be displayed. If an **F** (Fail display) is obtained, check for the following causes and correct.*

- *Other nuclear devices nearby*
- *Device not seated solidly on the reference block*
- *Device base or top of reference block not clean*

- *Reference block not the correct one for the nuclear device*

10. If an **F** appears after the percentages, make certain all obvious possible causes of a failed percentage are considered and corrected (such as the seating of the gauge on the block, debris between the gauge and block, etc). Press **YES** to accept the failing standard count. Continue to take standard counts regardless of whether or not the cause of the failing percentage is identified. Accept each failing standard count by pressing **YES** until the counts begin to pass. Continue to take standard counts until there are **4** passing counts in the gauge memory. This process will purge the gauge of failing standards. If numerous attempts to get a passing standard fails, contact the Testing Equipment Unit at the Materials & Testing Section for assistance and evaluation. When the display indicates that the density standard counts (DS) are within passing limits, record the value displayed as DS on the worksheet. Record the value displayed for the moisture standard count, as MS on the worksheet. These counts shall also be recorded on the Standard Count Log available with each device.
11. Press the **YES** key to accept the new standard counts and store them in the memory of the nuclear device. These standard counts will remain in the nuclear device's memory and be used for the calculation of data until a new set of standard counts is obtained and stored.

B. Frequency

1. Take standard counts at least once each day when the nuclear device has been idle for 4 hours or more and when test results are suspected of being in error.
2. If tests are to be taken where the nuclear device must be placed less than 2 m (6 ft) from an object (e.g., near a wall or in a trench) determine the density and moisture standard counts at each test location, using the trench offset factor procedure, outlined in Step III.C. These counts shall not be entered in the Standard Count Log.
3. If the day-to-day shift in standard count is greater than 2% for moisture or 1% for density as compared to the average of the previous four sets, there is a possibility of a device malfunction or operator error in placing the device on the standard block. Since the radiation source may cause this degree of shift, a second attempt to acquire usable standard counts is permissible. If instability is suspected, four or five sets of standard counts may be performed. If the highest and lowest counts are different by more than 25 for density or 12 for moisture, the device is to be returned to the Materials and Testing Section for a complete stability check. If over a period of several months, the cumulative shift in standard counts exceeds 4% for moisture or 2% for density, the calibration of the device is to be checked.

C. Trench Offset Factor

Note A-3: *Prior to determining the trench offset factor, the standard count should be determined in accordance with Step III.A.1 - 12.*

1. Select a random test location at the area where the actual test will be taken.

2. Arrange the reference standard block and device in accordance with Step III.A.1 – 5, except that the reference standard block will be set at the exact location as selected for the test.
3. Press the **OFFSET** key to obtain the first display. The display will show the offset selections, similar to the following example.

Method A

OFFSET – Select:
1 – Dens. –OFF
2 – Moist –OFF
3 – Trench - OFF-

4. Press the **3** key to select the trench offset. The resulting display will be similar to the following example.

Trench Offset
DISABLED
Want to use
Trench Offset?

5. Press the **YES** key to obtain the following display:

Trench Offset
constant =
Want to change?

6. Press the **YES** key to obtain the following display:

Rod -> SAFE pos.
Press START for
1 min. STD cnt.
in trench.

7. Press the **START** key to begin a one minute count. After counting down to zero, the display will be similar to the following example.

New TR. Offset
constant =
Want to change?

8. Press the **YES** key. The device will return to the **(READY)** mode.

Note A-4: *The trench offset factor must be changed for each new test location where the factor is required by repeating the preceding procedure.*

Note A-5: *Once enabled, the trench offset factor is retained in memory and will affect all future test results until the gauge is turned off or the function is disabled from the device keypad. Therefore, the trench offset must be disabled prior to performing the next test. Disable the trench offset factor by following Steps III.C.3 – 5, except that the **NO** key should be pressed in Step 5.*

IV. Procedure

A. Site Location

1. Select a test location greater than 2 m (6 ft) from an object. If the test location must be within 2 m (6 ft) of an object, standard moisture and density counts utilizing the trench offset procedure, outlined in Step III.C, shall be taken at each test location before density testing and shall not be entered in the Standard Count Log.
2. When it is not necessary to match the exact location at which the maximum dry weight density was determined, select the test site randomly in accordance with the Materials Sampling Manual.

Note A-6: *When in-place density is to be compared with moisture-density relationships determined in accordance with DOTD TR 415 for percent compaction, the test site for in-place density shall be the same location as the original site that material was obtained for the moisture-density relationships.*

B. Testing

Note A-7: *The nuclear device shall be set to obtain a one minute test count. The time for which the nuclear device is set will be displayed when it is in the (READY) mode. If the nuclear device does not indicate a one minute count, the Manual of Operation and Instruction shall be consulted for the method of resetting the time of the test count.*

1. Enter the maximum dry density, obtained from DOTD TR 418 or DOTD TR 415, into the nuclear device by pressing the **PROCTOR?MARSHALL** key. The display will show the last theoretical dry densities entered and a question, similar to the following example.

MA = 132.5
PR = 110.2
KD = 0.0
Do you want to
Make a change?

2. Press the **YES** key to make a change in the PR. The display will ask which one to change, similar to the following example.

**Which one to
change?
1 – MA
2 – PR
3 – VOIDLESS**

3. Select **2** and press ENTER, if required. The display will read similar to the following example.

**PR = 110.2
Press ENTER
when complete.**

Note A-8: *Models may include additional steps which are not shown here. Contact the District Laboratory Engineer for guidance.*

4. Enter the maximum dry density by pressing each number and decimal point in sequence on the keypad. The display will show the maximum dry density similar to the following example. Each number and the decimal point will be displayed as it is pressed.

   Record the maximum dry density as PR on the worksheet.

PR = 116.5

5. Store the maximum dry density (PR) in the device memory by pressing the **ENTER** key. This maximum dry density will be used to determine the percent density until a new theoretical dry weight density is stored in memory. Record on the worksheet as PR.
6. Using the scraper plate, scrape and lightly tamp an area in an approximately 1 m (3 ft) diameter circle around the intended probe location. Remove all loose stones or surface materials and fill small voids with native fines or sand.
7. Seat the device solidly on the prepared site with the probe at the location of the intended access hole to check surface preparation and levelness. Mark location and orientation of the device, then remove it.
8. Density and Moisture Testing
   a. Identify and set the test depth to be used.

Note A-9: *The test depth shall be the deepest setting possible that will not penetrate beneath the lift of material being tested.*

   b. Using the scraper plate/drill rod guide, the drill rod and maul, place the scraper plate at the location prepared in Step IV.B and punch an access hole. Punch the access hole at least 50 mm (2 in.) deeper than the test depth to be used. Place one foot on the rod guide plate while driving the rod into the material.

c. Remove the rod by pulling straight up in order to avoid disturbing the access hole. Use the extraction tool, if necessary.
d. Place the nuclear device on the prepared surface in the exact location and orientation as in Step IV.B.7. Insert the source rod into the access hole to the predetermined test depth.
e. Seat the nuclear device solidly by rotating it about the source rod using a back and forth rotational motion. Be sure that the entire bottom of the device is in complete contact with the prepared surface of the material to be tested. The source rod must also be in contact with the side of the hole adjacent to the detector tube.
f. After the device is seated, if there are still voids between the bottom of the nuclear device and the prepared surface to be tested, fill these minor depressions with native fines or sand, and reseat the nuclear device. Do not build up the area where the nuclear device is to be in contact with the surface.
g. Press **START/ENTER** on the keypad to begin the test counts. The display will be similar to the following example.

Depth: 6 in.
PR: 116.5 PCF
Time: 60 sec

h. After the 60 sec count period, the device will display percent density (%PR), dry density of test (DD), wet density of test (WD), the moisture in kg/m^3 (lb/ft^3) (M), and the percent moisture (%M). (%M is an instantaneous moisture and is not to be used in any calculations or as moisture control.) The display will appear similar to the following example.

%PR = 99.8%
DD = 116.3 PCF
WD = 122.5 PCF
M = 6.2 %M = 5.3

i. Record the percent density of test as %NPR on the worksheet.
j. Record the dry density of test as NDD for test 1 on the worksheet.
k. Record the wet density of test as WD for test 1 on the worksheet.
l. Record moisture in kg/m^3 (lb/ft^3) as M for test 1 on the worksheet. The value for DD should be verified to ensure accuracy of the value obtained due to possible rounding errors encountered with this model.

Note A-10: *To obtain the density test count (DC) and moisture test count (MC), the **SHIFT** key and shift function keys must be used. **SHIFT** and shift function keys are color coded yellow. The **SHIFT** key must be pressed before pressing a function key. Pressing the SHIFT key causes the display's top line to change to **(SHIFT/FUNCTION)**. After the SHIFT key is pressed, you have four seconds to press the proper function key. If a function key is not pressed within four seconds, the device will react as if no key had been pressed.*

m. Obtain the density count and moisture count by depressing the SHIFT key and the counts key (yellow coded on the top of the "1" key). The display will appear similar to the following example.

Dens ct. = 3666
Moist ct. = 185
SHIFT/RECALL to see Readings

n. Record the density count as DC for test 1 on the worksheet.
o. Record the moisture count as MC for test 1 on the worksheet.
p. Repeat Steps IV.B.7 and IV.B.8 d – n for test 2 and 3, as outlined on page 1, and record on the worksheet. If the dry density of any test is more than 50 kg/m^3 (3 lb/ft^3) below the highest dry density of the three test, reseat the nuclear device in the same orientation as the original test and rerun that test to verify the results. Use the higher of the two test results (original and retest) to calculate percent density. Record retest on additional forms.

Note A-11: *When a test is taken within 5 ft of a vertical surface, pipe, structure, etc. take only one test.*

q. Average the values of NDD and %NPR (if applicable) and record as ADD and %PR, respectively, on the worksheet.

Note A-12: *To recall the last test taken, press **SHIFT**, then press the **RECALL** key. The display will show the results of the last test taken, similar to the following example.*

%PR = 99.8%
DD = 116.3 PCF
WD = 122.5 PCF
M = 6.2 %M = 5.3

V. Report

A. Optimum Moisture Content (OM) from DOTD TR 418 or TR 415 to the nearest 0.1%.
B. Average Dry Density (ADD) to the nearest 1 kg/m^3 (0.1 lb/ft^3).
C. Maximum Dry Density (PR) to the nearest 1 kg/m^3 (0.1 lb/ft^3).
D. Percent Density (%PR) to the nearest 0.1%.
E. Nuclear Device Number and Inspector Nuclear Film Badge Number.
F. Family of Curves Number (if applicable).

VI. Normal Test Reporting Time

Normal test reporting time is 20 minutes

MATT MENU SELECTION - 07

Louisiana Department of Transportation and Development
DENSITY & MOISTURE CONTENT WORK SHEET

DOTD 03-22- 0750
Metric/ English
Rev. 12/98

Metric/English (M or E) [ ] *(Entry Field Located on Menu)*

Project No. 999-999-9999 **Date Tested** 1-1-16-94 **Material Code** 421

Submitted By 0071 **Purpose Code** 1 **Spec. Code** 3

Test Method N *N = Nuclear S = Sand Cone* **Item Number** 310 (011)

Station Tested 14 + 315 **Section & Test No.** 018-0011

Location: _____ Lift No: _____ Depth of Test: _____

OM:	Optimum % Moisture Content of Total Material (TR 415 or TR 418)	OM	[ ]°
%FM:	Field % Moisture Content at Compaction (TR 403) *(See back for calculations)*	%FM	[ ]°
P_1:	% Pulverization 19mm (3/4" SIEVE) (TR 431) *(See back for calculations)*	P_1	95
P_2:	% Pulverization 4.75mm (NO.4 SIEVE) (TR 431) *(See back for calculations)*	P_2	57

(TR 415) Cross Reference Test No.	Sta. No.:		Max. Dry Density Method [ ] *(1 = TR 415 A 2 = TR 415 B 3 = TR 418)*
a: Total Wet Mass (Wt.) of Sample			
b: Mass (Wt.) of +4.75 (+4) Material			
c: % By Mass (Wt.) of 4.75 (+4)Retained (100 b/a)			
d: Mass (Wt.) of Mold & Soil			
e: Mass (Wt.) of Mold			
f: Mass (Wt.) of Compacted Soil (d - e)			
g: Wet Density (f / 0.944) or (f / 2.832) or (f / 2.124) or (f / 0.075) (f x 30) or (f x 10) or			
h: Mass (Wt.) of Wet Soil			
i: Mass (Wt.) of Dry Soil			
j: Mass (Wt.) of Water (h - i)			
k: % Moisture Content (100 j/i) (TR 403)			
l: Dry Density 100g / (100 + k)			

om *(from Family of Curves)*: _____ pr *(from Family of Curves)*: _____ FAMILY OF CURVES ZONE NUMBER [ ]

SAND METHOD (TR 401)		NUCLEAR METHOD (TR 401)			
		Nuclear Device Number [ ] Insp. (Nuclear Badge No.) [ ]	Test 1	Test 2	Test 3
SA: Mass (Wt.) of Sand in Mold		DS: Density Standard Count	3540	3540	3540
SB: Vol. of Mold		DC: Density Test Count	3666	3645	3690
SC: Unit Mass (Wt.) of Sand (SA/SB)		DR: Density Count Ratio (DC / DS)	1.036	1.030	1.042
SD: Orig. Mass (Wt.) of Sand		WD: Wet Density	122.5	123.0	122.0
SE: Final Mass (Wt.) of Sand		MS: Moisture Standard Count	660	660	660
SF: Mass (Wt.) of Sand in Cone (SD-SE)		MC: Moisture Test Count	185	189	187
SG: Orig. Mass (Wt.) of Sand		MR: Moisture Count Ratio (MC / MS)	0.280	0.286	0.283
SH: Final Mass (Wt.) of Sand		M: Moisture by Mass (Wt.)	6.2	6.4	6.3
SI: Mass (Wt) of Sand in Cone & Hole (SG-SH)		MP: Moisture by Percent - *TR 401* ☐ / *TR 403* ☐	5.3	5.5	5.4
SJ: Mass (Wt.) of Sand in Hole (SI-SF)		NDD: Dry Density (WD - M) or $\frac{100 \times WD}{100 + MP}$	116.3	116.6	115.7
SV: Vol. of Hole (SJ/SC)		%NPR: % Density (NDD / PR) x 100	99.8	100.1	99.3
SW: Dry Mass (Wt.) of Material		ADD: Average Dry Density (NDD) or (NDD/3)		116.2	
SDD: Dry Density (SW / SV)		PR: Maximum Dry Density (TR 415/TR 418)		116.5	
PR: Maximum Dry Dens. (TR 415 / TR 418)		%PR: % Dens.(Nuclear) (% NPR) or (% NPR/3)		99.7	
%PR: % Density (Sand) (SDD / PR) x 100					

Remarks [ ]

_____ *(Signature)*

Density & Moisture Content Worksheet – Front
Figure A-1

Pulverization, P_1 and P_2 (TR 431)

* Test No. * *Utilize as many columns as necessary per test section.*		1	2	3	4
Adjusted Wet Mass (Wt) Sample (A)		1984			
Mass (Wt) of + 19 mm (3/4 in) Material (B_1)		95			
Mass (Wt) of + 4.75 mm (No. 4) Material (B_2)		750			
% Pulverization 19 mm (3/4 in) (P_1)	$100 \times \frac{(A - B_1)}{A}$	95%			
% Pulverization 4.75 mm (No. 4) (P_2)	$100 \times \frac{A - (B_1 + B_2)}{A}$	57%			

Field Moisture Content at Compaction, % FM (TR 403)

* Test No. * *Utilize as many columns as necessary per test section.*		1	2	3	4
Total Wet Mass (Wt) of Matl. at Compaction (A)					
Total Dry Mass (Wt) of Matl. at Compaction (B)					
Mass (Wt) of Water (C)	(A - B)				
% Field Moisture Content (% FM)	$100 \times \frac{C}{B}$				

Optimum Moisture and Maximum Dry Density Adjustments for Material Containing 20% - 60 % Silliceous Aggregate (TR 415)

		1	2	3
Optimum % Moist. of Tot. Material, (OM)	$OM = [(\frac{100 - c}{100}) \times om] + \frac{c}{100}$			
Maximum Dry Density, lb/ft³ (PR) *(English)*	$PR = \frac{160 \times pr \times z}{\frac{c}{100} \times pr \times z + [160 \times (1 - \frac{c}{100})]}$			
Maximum Dry Density, kg/m³ (PR) *(Metric)*	$PR = \frac{2564 \times pr \times z}{\frac{c}{100} \times pr \times z + [2564 \times (1 - \frac{c}{100})]}$			

Density & Moisture Content Worksheet – Back
Figure A-1

METRIC/ENGLISH

DOTD Designation: TR 401-02
Method B – Troxler Model 3411

I. Scope

A. This method of test is designed to determine the in-place density of soils, aggregates, or soil-aggregate mixtures, untreated, treated or stabilized, using the Troxler Model 3411 nuclear device.

B. Reference Documents
   1. DOTD TR 403 – Determination of Moisture Content.
   2. DOTD TR 415 – Field Moisture – Density Relationships.
   3. DOTD TR 418 – Moisture – Density Relationships.

II. Apparatus

A. Approved Troxler Model 3411 nuclear device – with locks and keys.
B. Operator's manual – for nuclear device.
C. Transport case – for nuclear device, with locks and keys.
D. Reference standard block
E. Scraper plate/drill rod guide
F. 19 mm (¾-inch) drill rod or 19 mm (¾-inch) auger.
G. Extraction tool (optional)
H. Standard Count Log
I. Operator's nuclear film badge and operator's license
J. Dry fine sand
K. Hand tools – 2 - 3 kg (4 – 6 lb) maul, shovel, straightedge
L. Worksheet – Moisture and Density Content Worksheet, DOTD Form No. 03-22-0750 (Figure B-1)

I. Standardization

A. Procedure
   1. Activate the device by turning the **POWER/TIME** switch with positions **OFF, NORM, SLOW, or FAST** to **SLOW**. The **PWR/TIME** switch turns the unit on and selects the time period for an accumulation. The **SLOW, NORM**, or **FAST** positions correspond to periods of 4, 1, or 0.25 min, respectively for accumulation purposes.
   2. Warm up the device for at least 10 min after turning it on before taking any count. Use the **SLOW** position for all standard counts; use **NORM** position for all test counts.
   3. With the probe retracted, clean the top of the reference standard block, being sure that there is no soil or other material which would prevent a good seat between the device and the block.
   4. With the probe retracted, clean the base of the device, being sure that there is no soil or other material which would prevent a good seat between the device and the block.
   5. Place the reference standard block on the compacted material with a minimum density of 1600 kg/m³ (100 lb/ft³) at least 2 m (6 ft) from any large object and at least 10 m (30

ft) from any other nuclear device. Any time a test is to be performed in an area with less than a 2 m (6 ft) clearance from an object (e.g., near a wall, pipe, vehicle or in a trench), the standard counts shall be taken on the same place as the test counts and for each test and shall not be entered in the standard count log.

6. Place the device on the reference standard block with the source rod in **SAFE** position, making sure there is a good seat between the device and the block.

Note B-1: *The keyboard is color coded for ease of use. Five keys have dual functions. The large yellow SHIFT key determines the mode of the dual function keys. The functions labeled in yellow (**STANDARD, %MA, %PR,** and **TST**) are operational when the shift key is depressed. The functions labeled in white are operational when the shift key is not depressed.*

7. Take a set of standard counts as follows:
   a. Turn the **POWER/TIME** switch to **SLOW**.
   b. Depress and hold the key labeled **SHIFT**.
   c. Depress the **STANDARD** key and release it.
   d. Release the **SHIFT** key.
   e. At the end of the SLOW TIME PERIOD (4 min), the standard count will be retained in memory until another set of counts is taken or the device is turned off.
   f. To obtain the density standard count, depress the key labeled **DS**. The number which appears in the instrument display is the density standard count.
   g. To obtain the moisture standard count, depress the key labeled **MS**. The number which appears in the instrument display is the moisture standard count.
8. Record the density standard count as **DS** on the worksheet. Record the moisture standard count as **MS** on the worksheet. Record both standard counts in the Standard Count Log.

B. Frequency
1. Take standard counts at least once each day; when the gauge has been idle for 4 hr or more or when test results are suspected of being in error.
2. If tests are to be taken where the nuclear device must be placed less than 2 m (6 ft) from an object (e.g., near a wall or in a trench), the density and moisture counts shall be taken at each test location. These counts shall not be entered in the Standard Count Log.
3. If the day-to-day shift in the standard count is greater than 2% for moisture or 1% for density as compared to the average of the previous four sets, there is a possibility of a device malfunction or operator error in placing the device on the standard block. Since the radiation source may cause this degree of shift, a second attempt to acquire usable standard counts is permissible. If instability is suspected, four or five sets of standard counts may be performed. If the highest and lowest counts are different by more than 25 for density or 12 for moisture, the device is to be returned to the DOTD Materials and Testing Section for a complete stability check. If over a time period of several months, the cumulative shift in standard counts exceeds 4% for moisture or 2% for density, the calibration of the device is to be checked.

II. Procedure

A. Site Location

1. Select a test location greater than 2 m (6 ft) from an object. If the test location must be within 2 m (6 ft) of an object, standard moisture and density counts shall be taken at each test location before density testing and shall not be entered in the standard count log.
2. When it is not necessary to match the exact location at which the maximum dry density was determined, select the test site randomly in accordance with the Materials Sampling Manual.

Note B-2: *When in-place density is to be compared with moisture-density relationships determined in accordance with DOTD TR 415 for percent compaction, the test site for in-place density shall be the same location as the original site that material was obtained for the moisture-density relationships.*

B. Testing

Note B-3: *The Model 3411 nuclear density gauge can display density results in either pounds per cubic foot or kilograms per cubic meter. The "PCF-SI" Switch is located on the underside of the scaler board, and can be accessed by removing the four knurled screws at each corner of scaler. Placing the switch in the PCF position will cause the gauge to display densities in lb/ft³, and the SI position will display densities in kg/m³. The DEPTH switch on the Model 3411 gauge is incremented in inches and cannot be set to display metric units. The following represent metric equivalents to the settings on the DEPTH switch.*

2 in.	=	*50 mm*
4 in.	=	*100 mm*
6 in.	=	*150 mm*
8 in.	=	*200 mm*
10 in.	=	*250 mm*
12 in.	=	*300 mm*

1. Warm up the equipment at least ten minutes.
2. Set the control functions as follows.
   a. Set the **POWER/TIME** switch to **NORM**.
   b. Set the **DEPTH** switch to the specified depth for the test.

Note B-4: *The test depth shall be the deepest setting possible that will not penetrate beneath the lift of material being tested.*

   c. Set the moisture correction switches to **+**, **0**, and **0**, respectively.
3. Test Site Preparation

a. Using the scraper plate, scrape and lightly tamp an area in an approximately 1 m (3 ft) diameter circle around the intended probe location. Remove all loose stones or surface materials and fill small voids with native fines or sand.
b. Using the scraper plate/drill rod guide, the drill rod and maul, place the scraper plate at the location prepared in Step IV.B.3.a and punch an access hole. Punch the access hole at least 50 mm (2 in.) deeper than the test depth to be used. Place one foot on the rod guide plate while driving the rod into the material.
c. Remove the rod by pulling straight up in order to avoid disturbing the access hole, using the extraction tool, if necessary.
d. Place the nuclear device on the prepared surface in the exact location and orientation as in Step 3.b., with the source rod inserted in the access hole to the predetermined test depth.
e. Seat the nuclear device solidly by rotating it about the source rod using a back and forth rotational motion. Be sure that the entire bottom of the device is in complete contact with the prepared surface of the material to be tested. The source rod must also be in contact with the side of the hole adjacent to the detector tube.
f. After the device is seated, if there are still voids between the bottom of the device and the prepared surface to be tested, fill these minor depressions with native fines or sand, and reseat the device. Do not build up the area where the device is to be in contact with the surface.

4. Density and Moisture Testing
   a. Push the **MEASURE** button to begin the test counts.
   b. When the device stops counting, the timing period has expired. Depress the button labeled DC to obtain the density test count. Record the density test count as DC for test 1 on the worksheet.
   c. Depress the button labeled **MC** for the moisture test count and record the moisture test count as MC for test 1 on the worksheet.
   d. Depress WD for wet density in kilograms per cubic meter (pounds per cubic foot). Record wet density as WD for test 1 on the worksheet.
   e. Depress **WD** for moisture content in kilograms per cubic meter (pounds per cubic feet) and record as M for test 1 on the worksheet.
   f. Depress **DD** for dry density and record as NDD for test 1 on the worksheet.
   g. Repeat Steps 3.b and 3.e – 4.f for tests 2 and 3, as outlined in the introduction, and record.

Note B-5: *When test is taken within 2 m (6 ft) of a wall, pipe, or other structure, take only one test.*

   h. Calculate %NPR for each test and record.
   i. Average the values of NDD and %NPR (if applicable) and record as ADD and %PR, respectively, on the worksheet. If the dry density of any test is more than 50 kg/m³ (3 lb/ft³) below the highest dry density of the three tests, reseat the device in the same orientation as the original test and rerun that test to verify the results. Use the higher of the two test results (original and retest) to calculate percent density. Record restarts on additional form.

V. Calculations

Calculate the percent density (%NPR) using the following formula.

$$\%NPR = \frac{NDD}{PR} \times 100$$

Where:

PR = theoretical dry density, kg/m³ (lb/ft³)
ND = dry density of test, kg/m³ (lb/ft³)

III. Report

A. Optimum moisture content (OM) DOTD TR 418 or TR 415 to the nearest 0.1%.
B. Average dry density (ADD) to the nearest 1 kg/m³ (0.1 lb/ft³).
C. Maximum dry density (PR) to the nearest 1 kg/m³ (0.1 lb/ft³).
D. Percent density (%PR) to the nearest 0.1%.
E. Nuclear device number and Inspector Nuclear Film Badge number.
F. Family of curves number (if applicable).

VI. Normal Test Reporting Time

Normal test reporting time is 20 minutes.

MATT MENU SELECTION - 07

Louisiana Department of Transportation and Development
DENSITY & MOISTURE CONTENT WORK SHEET

DOTD 03-22- 0750
Metric/ English
Rev. 12/98

Metric/English (M or E) [ ] *(Entry Field Located on Menu)*

Project No. 999-99-9999 Date Tested 1-16-94 Material Code 421

Submitted By 0011 Purpose Code 1 Spec. Code 3

Test Method N *N = Nuclear S = Sand Cone* Item Number 310 (011)

Station Tested 14 + 35 Section & Test No. 108-1001

Location: _____ Lift No: _____ Depth of Test: _____

OM:	Optimum % Moisture Content of Total Material (TR 415 or TR 418)	OM	
%FM:	Field % Moisture Content at Compaction (TR 403) *(See back for calculations)*	%FM	
P_1:	% Pulverization 19mm (3/4" SIEVE) (TR 431) *(See back for calculations)*	P_1	95
P_2:	% Pulverization 4.75mm (NO.4 SIEVE) (TR 431) *(See back for calculations)*	P_2	57

(TR 415) Cross Reference Test No.	Sta. No.:		Max. Dry Density Method *(1 = TR 415 A 2 = TR 415 B 3 = TR 418)*
a: Total Wet Mass (Wt.) of Sample			
b: Mass (Wt.) of +4.75 (+4) Material			
c: % By Mass (Wt.) of 4.75 (+4)Retained (100 b/a)			
d: Mass (Wt.) of Mold & Soil			
e: Mass (Wt.) of Mold			
f: Mass (Wt.) of Compacted Soil (d - e)			
g: Wet Density (f / 0.944) or (f / 2.832) or (f / 2.124) (f x 30) or (f x 10) or (f / 0.075)			
h: Mass (Wt.) of Wet Soil			
i: Mass (Wt.) of Dry Soil			
j: Mass (Wt.) of Water (h - i)			
k: % Moisture Content (100 j/i) (TR 403)			
l: Dry Density 100g / (100 + k)			

om *(from Family of Curves)*: _____ pr *(from Family of Curves)*: _____ FAMILY OF CURVES ZONE NUMBER [ ]

SAND METHOD (TR 401)		
SA: Mass (Wt.) of Sand in Mold		
SB: Vol. of Mold		
SC: Unit Mass (Wt.) of Sand (SA/SB)		
SD: Orig. Mass (Wt.) of Sand		
SE: Final Mass (Wt.) of Sand		
SF: Mass (Wt.) of Sand in Cone (SD-SE)		
SG: Orig. Mass (Wt.) of Sand		
SH: Final Mass (Wt.) of Sand		
SI: Mass (Wt) of Sand in Cone & Hole (SG-SH)		
SJ: Mass (Wt.) of Sand in Hole (SI-SF)		
SV: Vol. of Hole (SJ/SC)		
SW: Dry Mass (Wt.) of Material		
SDD: Dry Density (SW / SV)		
PR: Maximum Dry Dens. (TR 415 / TR 418)		
%PR: % Density (Sand) (SDD / PR) x 100		

NUCLEAR METHOD (TR 401)			
Nuclear Device Number [ ] Insp. (Nuclear Badge No.) [ ]	Test 1	Test 2	Test 3
DS: Density Standard Count	3540	3540	3540
DC: Density Test Count	3666	3645	3690
DR: Density Count Ratio (DC / DS)	1.036	1.030	1.042
WD: Wet Density	122.5	123.0	122.0
MS: Moisture Standard Count	660	660	660
MC: Moisture Test Count	185	189	187
MR: Moisture Count Ratio (MC / MS)	0.280	0.286	0.283
M: Moisture by Mass (Wt.)	6.2	6.4	6.3
MP: Moisture by Percent - *TR 401* ☐ / *TR 403* ☐	5.3	5.5	5.4
NDD: Dry Density (WD - M) or $\frac{100 \times WD}{100 + MP}$	116.3	116.6	115.7
%NPR: % Density (NDD / PR) x 100	99.8	100.1	99.3
ADD: Average Dry Density (NDD) or (NDD/3)	116.2		
PR: Maximum Dry Density (TR 415/TR 418)	116.5		
%PR: % Dens.(Nuclear) (% NPR) or (% NPR/3)	99.7		

Remarks [ ]

_____ *(Signature)*

Density & Moisture Content Worksheet – Front
Figure B-1

Pulverization, P_1 and P_2 (TR 431)

* Test No. * *Utilize as many columns as necessary per test section.*		1	2	3	4
Adjusted Wet Mass (Wt) Sample (A)		1984			
Mass (Wt) of + 19 mm (3/4 in) Material (B_1)		95			
Mass (Wt) of + 4.75 mm (No. 4) Material (B_2)		750			
% Pulverization 19 mm (3/4 in) (P_1)	$100 \times \frac{(A - B_1)}{A}$	95%			
% Pulverization 4.75 mm (No. 4) (P_2)	$100 \times \frac{A - (B_1 + B_2)}{A}$	57%			

Field Moisture Content at Compaction, % FM (TR 403)

* Test No. * *Utilize as many columns as necessary per test section.*		1	2	3	4
Total Wet Mass (Wt) of Matl. at Compaction (A)					
Total Dry Mass (Wt) of Matl. at Compaction (B)					
Mass (Wt) of Water (C)	(A - B)				
% Field Moisture Content (% FM)	$100 \times \frac{C}{B}$				

Optimum Moisture and Maximum Dry Density Adjustments for Material Containing 20% - 60 % Siliceous Aggregate (TR 415)

		1	2	3
Optimum % Moist. of Tot. Material, (OM)	$OM = [(\frac{100 - c}{100}) \times om] + \frac{c}{100}$			
Maximum Dry Density, lb/ft³ (PR) *(English)*	$PR = \frac{160 \times pr \times z}{\frac{c}{100} \times pr \times z + [160 \times (1 - \frac{c}{100})]}$			
Maximum Dry Density, kg/m³ (PR) *(Metric)*	$PR = \frac{2564 \times pr \times z}{\frac{c}{100} \times pr \times z + [2564 \times (1 - \frac{c}{100})]}$			

Density & Moisture Content Worksheet - Back
Figure B-1

DOTD Designation: TR 401
Method C – HUMBOLDT MODEL HS-5001 EZ

I. Scope

A. This method of test is designed to determine the in-place density of soils, aggregates, or soil-aggregate mixtures, untreated, treated or stabilized, using the Humboldt Model HS-5001 EZ nuclear device

B. Reference Documents
   1. DOTD TR 403 – Determination of Moisture Content.
   2. DOTD TR 415 – Field Moisture – Density Relationships.
   3. DOTD TR 418 – Moisture – Density Relationships.

II. Apparatus

A. Approved Humboldt Model HS-5001 EZ nuclear device – with locks and keys.
B. Operator's manual – for nuclear device.
C. Transport case – for nuclear device, with locks and keys.
D. Reference standard block
E. Scraper plate/drill rod guide
F. 19 mm (¾-inch) drill rod or 19 mm (¾-inch) auger.
G. Extraction tool (optional)
H. Standard Count Log
I. Operator's nuclear film badge and operator's license
J. Dry fine sand
K. Hand tools – 2 - 3 kg (4 – 6 lb) maul, shovel, straightedge
L. Calibration charts – for density and moisture
M. Worksheet – Moisture and Density Content Worksheet, DOTD Form No. 03-22-0750 (Figure C-1 front and back)

III. Standardization

A. Procedure
   1. Turn the device on by pressing the **PWR** key. Allow the device to warm up for fifteen (15) minutes. The device will automatically go through a five second self-test routine.

Note C-1: *Do not turn the device off while the self-test display is on. Turning the device off while the self-test display is on may result in the loss of device memory.*

   2. Clean the top of the reference standard block, being sure that there is no soil or other material which would prevent a good seat between the device and the block.
   3. With the probe retracted, clean the base of the device, being sure that there is no soil or other material which would prevent a good seat between the device and the block.
   4. Place the reference standard on the compacted material with a minimum density of 1600 kg/m³ (100 lb/ft³), at least 2 m (6 ft) from any large object and at least 10 m (30 ft) from any other nuclear device. When a test is to be performed in an area with less than a 2 m (6 ft) clearance from an object (e.g., near a wall, pipe, vehicle, or in a trench), the trench offset factor, as

determined in Step III.C should be utilized at the exact location as the test counts and shall not be entered in the Standard Count Log.

5. Place the device on the reference standard block with the source rod in **SAFE** position making sure there is a good seat between the device and the block. The label on the end of the gauge should be on the same end as the label on the standard block. The front of the gauge should be in contact with the label plate on the standard block.
6. Press the STD STAT key to begin the standard counts. The display will show the standard counts and offer two alternatives, similar to the following example.

DS = 3560 09/14/01
MS = 640 08:31
*** TAKE NEW STD**
*** USE CURRENT STD**

7. Press the **F3** key to take a new count and obtain the second display. The display will be similar to the following example.

TAKING STANDARD
TIME REMAINING 4:00
DS = 0000
MS = 000 Depth = SAF

8. When the standard count is completed, the device will beep and display the results of a four-minute standard count. If there are no errors, the results will be similar to the following example:

STD TEST RESULT
DS = 3540
MS = 660

Note C-2: *If there is an error, the display will read similar to the following:*

DS = 3500 %ERR = 1.0
MS = 640 %ERR = 3.0
***REJECT & TAKE NEW STANDARD**
***RETAIN THE NEW STANDARD**

The %ERR to the right of the density
and moisture standard counts indicate that the new counts exceed the 1% density and 2% moisture limits from the average standard counts stored in the memory. If the display shows a %ERR for either or both standard counts, check the following causes and correct:

- *Other nuclear devices nearby*
- *Device not seated solidly on the reference block*
- *Device base or top of reference block not clean*

- *Reference block not the correct one for the nuclear device.*

9. If the above conditions are normal, press **F4** (*RETAIN THE NEW STANDARD) and obtain a new standard count in accordance with Step III.A.7. Obtain new standard counts until the %ERR are within the limits shown in Step III.B.3 or until the fourth attempt is made. If, after four trials, the error still appears in the display, contact the District Laboratory Engineer or return the device to the Materials and Testing Section for evaluation.
10. When the display indicates that the density and moisture standard counts (DS & MS) are within passing limits as shown in Step 8, continue to take new standard counts until the gauge produces four consecutive passing standards. Record the value displayed after the last attempt as DS and MS on the worksheet. These counts shall also be recorded on the Standard Count Log available with each device.

A. Frequency

1. Take standard counts at least once each day when the nuclear device has been idle for 4hr or more or when test results are suspected of being in error.
2. If tests are to be taken where the nuclear device must be placed less than 2 m (6 ft) from an object (e.g., near a wall or in a trench), determine the density and moisture standard counts at each test location, using the trench offset factor procedure, outlined in Step III.C. These counts are not to be entered in the Standard Count Log.
3. If the day-to-day shift in standard counts is greater than 2% for moisture or 1% for density, as compared to the average of the previous four sets, there is a possibility of a device malfunction or operator error in placing the device on the standard block. Since the radiation source may cause this degree of shift, a second attempt to acquire usable standard count is permissible. If instability is suspected, four or five sets of standard counts may be performed. If the highest and lowest counts are different by more than 25 for density or 12 for moisture, the device is to be returned to the Materials and Testing Section for a complete stability check. If, over a period of several months, the cumulative shift in standard counts exceeds 4% for moisture or 2% for density, the calibration of the device is to be checked.

C. Trench Offset Factor

Note C-3: *Prior to determining the trench offset factor, the standard count should be determined in accordance with Steps III.A. 1 – 10.*

1. Select a random test location at the area where the actual test will be taken.
2. Arrange the reference standard block and device in accordance with Steps III.A.1 – 5, except that the reference standard block will be set at the exact location as selected fro the test.
3. Press the **Main Menu** key to obtain the first display as follows:

*** DATA 09/14/01**
*** SETUP 10:22**
*** ENGINEERING**
DEPTH = SAF

4. Press **F2** (*SETUP) to obtain the following display:

   *** SETUP 2**
   *** SET MEASURE MODES**
   *** SET TRNCH COR.**
   *** SET TARGETS**

5. Press **F3** (SET TRNCH COR.).

   *** Place Rod in SAFE**
   *** Place Ref in Trench**
   *** Place gauge on Ref**
   *** Press F4 to Begin**

6. Press the **F4** key to begin the four-minute count. The resulting display will be similar to the following:

   Trench Connection
   Time Remaining: 4:00
   DC = 3650
   MC = 720
   Depth = SAF

7. When the four-minute count is complete, the display will be similar to the following:

   Trench Connection
   Trench CF = -341.
   Ready for Measure

Note C-4: *The trench offset factor must be changed for each new test location where the factor is required by repeating the preceding procedure.*

Note C-5: *Once enabled, the trench offset factor is retained in memory and will affect all future test results until the gauge is turned off or the function is disabled from the setup menu. Therefore, a new standard count must be taken prior to performing tests outside the trench by following Steps III.A.3 – 10.*

IV. Procedure

A. Site Location

1. Select a test location greater than 2 m (6 ft) from an object. If the test location must be within 2 m (6 ft) of an object, standard moisture and density counts utilizing the trench offset procedure, outlined in Step II.C, shall be taken at each location before density testing and shall not be entered in the Standard Count Log.
2. When it is not necessary to match the exact location at which the maximum dry density was determined, select the test site randomly in accordance with the Materials Sampling Manual.

Note C-6: *When in-place density is to be compared with moisture-density relationships determined in accordance with DOTD TR 415 for percent compaction, the test site for in-place density shall be the same location as the original site that material was obtained for the moisture-density relationships.*

B. Testing

Note C-7: *The nuclear device shall be set to operate in the required units of measure, whether metric or English units, and to obtain a one-minute test count. The device will display densities in either kg/m³ or lb/ft³. Refer to the Humboldt model HS-5001 EZ User Guide for the methods of resetting the units of measure and the time of the test count if these changes are needed.*

1. Enter the maximum dry density, obtained from DOTD TR 418 or DOTD TR 415, into the nuclear device by pressing the **MAX "D"** key. The display will show the last maximum dry density entered. If not correct, press **F3** to increase the value or **F4** to decrease the value.
2. Using the scraper plate, scrape and lightly tamp an area approximately 1 m (3 ft) diameter circle around the intended probe location. Remove all loose stones or surface materials and fill small voids with native fines or sand.
3. Seat the device solidly on the prepared site with the probe at the location of the intended access hole to check surface preparation and levelness.
4. Density Testing
   a. Identify and set the test depth to be used.

Note C-8: *The test depth shall be the deepest setting possible that will not penetrate beneath the lift of material being tested.*

   b. Using the scraper plate/drill rod guide, the drill rod and maul, place the scraper plate at the location prepared in Steps IV.B.2 & 3 and punch an access hole. Punch the access hole at least 50 mm (2 in.) deeper than the test depth to be used. Place one foot on the rod guide plate while driving the rod into the material.
   c. Remove the rod by pulling straight up in order to avoid disturbing the access hole. Use the extraction tool, if necessary.
   d. Place the nuclear device on the prepared surface in the exact location and orientation as in Step IV.B.3. Insert the source rod into the access hole to the predetermined test depth.
   e. Seat the nuclear device solidly by rotating it about the source rod using a back and forth rotational motion. Be sure that the entire bottom of the device is in complete contact with the prepared surface of the material to be tested. The source rod must also be in contact with the side of the hole adjacent to the detector tube.
   f. After the device is seated, if there are still voids between the bottom of the device and the prepared surface to be tested, fill these minor depressions with native fines or sand, and reseat the device. Do not build up the area where the device is to be in contact with the surface.
   g. Push the MEAS on the keypad to begin the test counts. The display will be similar to the following example.

TAKING MEASUREMENT

TIME REMAINING 1:00
DC = 3540
MC = 660 DEPTH = 8

h. After the 60 sec count period, the device will display percent density (%PR), dry density of test (DD), wet density of test (WD), the moisture in kg/m³ (lb/ft³) (M), and the percent moisture (%M). (%M is an instantaneous moisture and is not to be used in any calculations or as moisture control.) The display will appear similar to the following example.

DD=116.3 %M=5.3
WD=122.5 M=62
%PR=99.8 Max D=116.5
***NEXT MDEPTH = 8**

i. Record the percent density of test as %NPR on the worksheet.
j. Record the dry density of test as NDD for test 1 on the worksheet.
k. Record the wet density of test as WD for test 1 on the worksheet.
l. Record moisture in kg/m³ (lb/ft³) as M for test 1 o the worksheet. The value for DD should be verified to ensure accuracy of the value obtained due to possible rounding errors encountered with this model.
m. Obtain the density count and moisture count by depressing **F4** (*NEXT). The display will appear similar to the following example.

DC = 3666 DS = 3540
MC = 185 MS = 660
VR = 0.35 %AV = 31.6
***LAST MDEPTH = 8**

n. Record the density count as DC for test 1 on the worksheet.
o. Record the moisture count as MC for test 1 on the worksheet.
p. Repeat Steps IV.B.7 and IV.B.8 d –n for tests 2 and 3, as outlined on page 1, and record on the worksheet. If the dry density of any test is more than 50 kg/m³ (3 lb/ft³) below the highest dry density of the three tests, reseat the nuclear device in the same orientation as the original test and rerun that test to verify the results. Use the higher of the two test results (original and retest) to calculate percent density. Record retest on additional forms.

Note C-9: *When a test is taken within 2 m (6 ft) of a vertical surface, pipe, structure, etc. take only one test.*

q. Average the values of NDD and % NPR (if applicable) and record as ADD and %PR, respectively, on the worksheet.

Note C-10: *To recall the density and moisture results from Step h, press **F4**.*

V. Report

A. Optimum moisture content (OM) DOTD TR 418 or TR 415 to the nearest 0.1%.

B. Average dry density (ADD) to the nearest 1 kg/m³ (0.1 lb/ft³).
C. Maximum dry density (PR) to the nearest 1 kg/m³ (0.1 lb/ft³).
D. Percent density (% PR) to the nearest 0.1%.
E. Nuclear device number and Inspector Nuclear Film Badge number.
F. Family of curves number (if applicable).

VI. Normal Test Reporting Time

Normal test reporting time is 20 minutes.

MATT MENU SELECTION - 07

Louisiana Department of Transportation and Development
DENSITY & MOISTURE CONTENT WORK SHEET

DOTD 03-22- 0750
Metric/ English
Rev. 12/98

Metric/English (M or E) [ ] *(Entry Field Located on Menu)*

Project No. 999-999-99999 Date Tested 11-16-94 Material Code 421

Submitted By 0071 Purpose Code 1 Spec. Code 3

Test Method N *N = Nuclear S = Sand Cone* Item Number 310 (011)

Station Tested 14 + 35 Section & Test No. 018-1001

Location: _____ Lift No: _____ Depth of Test: _____

OM:	Optimum % Moisture Content of Total Material (TR 415 or TR 418)	OM	
%FM:	Field % Moisture Content at Compaction (TR 403) *(See back for calculations)*	%FM	
P_1:	% Pulverization 19mm (3/4" SIEVE) (TR 431) *(See back for calculations)*	P_1	95
P_2:	% Pulverization 4.75mm (NO.4 SIEVE) (TR 431) *(See back for calculations)*	P_2	57

(TR 415) Cross Reference Test No.	Sta. No.:		Max. Dry Density Method [ ] *(1 = TR 415 A 2 = TR 415 B 3 = TR 418)*
a: Total Wet Mass (Wt.) of Sample			
b: Mass (Wt.) of +4.75 (+4) Material			
c: % By Mass (Wt.) of 4.75 (+4)Retained (100 b/a)			
d: Mass (Wt.) of Mold & Soil			
e: Mass (Wt.) of Mold			
f: Mass (Wt.) of Compacted Soil (d - e)			
g: Wet Density (f / 0.944) or (f / 2.832) or (f / 2.124) (f x 30) or (f x 10) or (f / 0.075)			
h: Mass (Wt.) of Wet Soil			
i: Mass (Wt.) of Dry Soil			
j: Mass (Wt.) of Water (h - i)			
k: % Moisture Content (100 j/i) (TR 403)			
l: Dry Density 100g / (100 + k)			

om *(from Family of Curves)*: _____ pr *(from Family of Curves)*: _____ FAMILY OF CURVES ZONE NUMBER [ ]

SAND METHOD (TR 401)		NUCLEAR METHOD (TR 401)			
		Nuclear Device Number [ ] Insp. (Nuclear Badge No.) [ ]	Test 1	Test 2	Test 3
SA: Mass (Wt.) of Sand in Mold		DS: Density Standard Count	3540	3540	3540
SB: Vol. of Mold		DC: Density Test Count	3666	3645	3690
SC: Unit Mass (Wt.) of Sand (SA/SB)		DR: Density Count Ratio (DC / DS)	1.036	1.030	1.042
SD: Orig. Mass (Wt.) of Sand		WD: Wet Density	122.5	123.0	122.0
SE: Final Mass (Wt.) of Sand		MS: Moisture Standard Count	660	660	660
SF: Mass (Wt.) of Sand in Cone (SD-SE)		MC: Moisture Test Count	185	189	187
SG: Orig. Mass (Wt.) of Sand		MR: Moisture Count Ratio (MC / MS)	0.280	0.286	0.283
SH: Final Mass (Wt.) of Sand		M: Moisture by Mass (Wt.)	6.2	6.4	6.3
SI: Mass (Wt) of Sand in Cone & Hole (SG-SH)		MP: Moisture by Percent - *TR 401* ☐ / *TR 403* ☐	5.3	5.5	5.4
SJ: Mass (Wt.) of Sand in Hole (SI-SF)		NDO: Dry Density (WD - M) or $\frac{100 \times WD}{100 + MP}$	116.3	116.6	115.7
SV: Vol. of Hole (SJ/SC)		%NPR: % Density (NDO / PR) x 100	99.8	100.1	99.3
SW: Dry Mass (Wt.) of Material					
SDD: Dry Density (SW / SV)		ADD: Average Dry Density (NDO) or (NDO/3)		116.2	
PR: Maximum Dry Dens. (TR 415 / TR 418)		PR: Maximum Dry Density (TR 415/TR 418)		116.5	
%PR: % Density (Sand) (SDD / PR) x 100		%PR: % Dens.(Nuclear) (% NPR) or (% NPR/3)		99.7	

Remarks [ ]

_____ *(Signature)*

Density & Moisture Content Worksheet - Front
Figure C-1

Pulverization, P_1 and P_2 (TR 431)

* Test No. * *Utilize as many columns as necessary per test section.*		1	2	3	4
Adjusted Wet Mass (Wt) Sample (A)		1984			
Mass (Wt) of + 19 mm (3/4 in) Material (B_1)		95			
Mass (Wt) of + 4.75 mm (No. 4) Material (B_2)		750			
% Pulverization 19 mm (3/4 in) (P_1)	$100 \times \frac{(A - B_1)}{A}$	95%			
% Pulverization 4.75 mm (No. 4) (P_2)	$100 \times \frac{A - (B_1 + B_2)}{A}$	57%			

Field Moisture Content at Compaction, % FM (TR 403)

* Test No. * *Utilize as many columns as necessary per test section.*		1	2	3	4
Total Wet Mass (Wt) of Matl. at Compaction (A)					
Total Dry Mass (Wt) of Matl. at Compaction (B)					
Mass (Wt) of Water (C)	(A - B)				
% Field Moisture Content (% FM)	$100 \times \frac{C}{B}$				

Optimum Moisture and Maximum Dry Density Adjustments for Material Containing 20% - 60 % Siliceous Aggregate (TR 415)

		1	2	3
Optimum % Moist. of Tot. Material, (OM)	$OM = [(\frac{100 - c}{100}) \times om] + \frac{c}{100}$			
Maximum Dry Density, lb/ft³ (PR) *(English)*	$PR = \frac{160 \times pr \times z}{\frac{c}{100} \times pr \times z + [160 \times (1 - \frac{c}{100})]}$			
Maximum Dry Density, kg/m³ (PR) *(Metric)*	$PR = \frac{2564 \times pr \times z}{\frac{c}{100} \times pr \times z + [2564 \times (1 - \frac{c}{100})]}$			

Moisture Content Worksheet - Back
Figure C-1