

ALDOT-222-82

IN-PLACE DENSITY AND MOISTURE MEASUREMENTS AND ESTABLISHING MOISTURE CORRELATIONS FOR NUCLEAR MOISTURE/DENSITY GAUGES

1. Scope

- 1.1. This method of test provides a non-destructive measurement of in-place density and moisture content of soils and/or aggregate bases.

Note 1: ALDOT operators shall have a current certification card issued by the Bureau of Materials and Tests after completion of the Radiation Safety Course, Earthwork Technician and Roadway Technician courses. Non-ALDOT operators shall have a current certification card issued by the Bureau of Materials and Tests after completion of the Earthwork Technician and Roadway Technician courses and must be licensed by the Alabama Department of Public Health (ADPH) to operate Nuclear Moisture/Density Gauges.

2. Applicable Documents

- ALDOT 460 Radiation Safety Officer Manual
- Approved Devices List II-21 Nuclear Gauges
- Manufacturers Operating Manual Supplied with gauge
- AASHTO T-265 Laboratory Determination of Moisture Content of Soils
- AASHTO T-310 In Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods
- AASHTO T-166 Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
- ALDOT-210 Selecting Samples by the Random Numbers Method.

3. Nuclear Gauging Device

- 3.1. Nuclear gauging devices must meet the requirements of ALDOT Approved Devices List II-21 Nuclear Gauges.

Note 2: Active nuclear moisture/density gauges must be verified on calibration standards at the Bureau of Materials and Tests Nuclear Lab at a minimum frequency of 12 months as per AASHTO T 310. Gauge accuracy will be required to be within +/- 1.5% (1.5 lbs.) of calibration standards.

4. Apparatus

- 4.1. Cans - Four cans with a capacity of 500 g minimum with lids to prevent loss of moisture.

5. Procedure for Standardizing Check of Equipment

- 5.1. Check the gauge against a reference standard at least twice a day or more frequently if climatic, transporting, background or other conditions necessitate.
- 5.2. Refer to the manufacturers operating manual, and if necessary, use the manufacturer's recommendations for warm-up. After warm-up take five four-minute counts on the gauge's reference standard block and average (to be used as a Standard Count).
- 5.3. The average for the five one-minute counts should be within the permissible variations set forth in Table 1. If any one individual count is outside of the statistical limits, a repeat of the entire count run is required.

Table 1: Acceptable Range of Count Variations Used for Standardizing and Calibrating Moisture Density Nuclear Gauges

Average Standard Counts (ASC)	Permissible Variations \pm (1.96 ASC)
70,000	\pm 520
45,000	\pm 415
36,000	\pm 375
16,000	\pm 250
7,000	\pm 165
4,000	\pm 125
3,000	\pm 107
2,000	\pm 88

- 5.4. When using a gauge that averages the standard count internally, the standard count must be performed and saved even when a failure is indicated for either moisture or density. Once a passing count is indicated for both moisture and density, the gauge is ready for operation.

Note 3: Nuclear gauges must be separated from one another and technicians by at least 10ft (3m) when standard counts are being taken.

6. Procedure For In-Place Density And Moisture Tests

- 6.1. In place density will be measured for acceptance in accordance with the requirements given in AASHTO T 310, "In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)", Direct Transmission Method only as modified by the following method:
- 6.2. Clear away all loose surface material or dried crust and obtain a plane sufficient in area to accommodate the gauge and extending 6 in. (150 mm) beyond the gauge housing.

- 6.3. Where sheepsfoot and similar type tamping rollers have been used, remove the loose surface material to a depth at least equal to the deepest penetration of the roller foot.
- 6.4. Modes of transmission shall be as follows:
 - 6.4.1. Direct - May be used on all materials exceeding 2 in. (50 mm) in thickness and will be required for embankment, roadbed and fine grained base layers.
 - 6.4.2. Backscatter - For high coarse aggregate content base layers.
 - 6.4.3. Backscatter/Air Gap - For very open graded high coarse aggregate content base layers.

Note 4: Careful seating of the gauge is necessary. The surface under the gauge must be plane. When direct transmission mode is used, the access hole for the probe must be perpendicular to the base plane. Minor depressions, not exceeding 0.13 in. (3 mm) may be filled with native fines removed from the layer being tested. (Ottawa sand or any fine sand may be substituted for native fines.)

- 6.5. Take one one-minute reading, recording both moisture and density counts.
- 6.6. The gauge shall be rotated 90° about the axis of the source rod and a second one-minute reading of moisture and density counts shall be taken and recorded.
- 6.7. When operating gauge within 24 in. (600 mm) of the edge of the road-bed or asphalt mat, use the following procedure. For initial reading, place gauge parallel to the edge of the layer being tested. Then, rotate gauge at 60° intervals (about the axis of the source rod for direct transmission or over the centerpoint of the gauge for backscatter) to obtain the next three (3) readings. The last reading should be taken opposite the first reading, leaving the gauge parallel to the edge of the layer being tested.

Note 5: Measurement counts should be repeated if any count varies more than \pm five (5) times the square root of the average.

Note 6: Nuclear gauges must be separated from one another and technicians by at least 10ft (3m) when in-place density and moisture tests are being taken.

7. Calculations

- 7.1. Wet density

$$R = \frac{n}{asc}$$

Where

R = wet density count ratio

n = average count for the one minute time readings for density probe

asc = average standard count for density probe

7.1.1. Wet density (D) in lbs/ft³(kg/m³). Locate R on calibration chart and record corresponding wet density (D) to nearest 0.25 lb (0.113 kg).

Note 7: Manufacturers supply a computer print-out for density and moisture measurements. These measurements are to the nearest 0.5 lb (0.227 kg) for density and 0.25 lb (0.113 kg) for moisture. To record to nearest 0.2 lb (0.0909 kg), interpolation is required for the density printout.

7.2. Moisture Content

$$R_1 = \frac{n_1}{asc_1}$$

Where

R₁ = moisture count ratio

n₁ = average count for the one minute time readings for moisture probe

asc₁ = average standard count for moisture probe

7.2.1. Moisture content (M) in lbs/ft³ (kg/m³). Locate R on calibration chart and record corresponding moisture content (M) to nearest 0.2 lb (0.113 kg).

7.3. Dry density in lbs/ft³ (kg/m³)

$$D_1 = D - M$$

Where

D₁ = dry density in lb/ft³ (kg/m³)

7.4. Percent moisture

$$P = \frac{M}{D_1} \times 100$$

Where

P = percent moisture (soil dry basis)

M = moisture content in lb/ft³ (kg/m³)

D₁ = dry density in lb/ft³ (kg/m³)

7.5. Percent comparative compaction

$$P = \frac{D_1}{D_2} \times 100$$

Where

P = percent of comparative compaction

D₁ = dry density in lbs/ft³ (kg/m³)

D₂ = control weight of material expressed in lbs/ft³ (kg/m³).

8. Correlation of Moisture and Density Curves

- 8.1. Correlation moisture curves, will be established at the start of the project for each gauge being used, for each type of material being compacted on the project, and when deemed necessary by the Project Engineer. Correlations of the moisture curves will be under the direction of the Materials and Tests Engineer. Moisture curves will be correlated to values determined by AASHTO T-265.
- 8.2. For a moisture correlation, run four separate density tests. Record wet density in lbs/ft³ (kg/m³) and moisture content in lbs/ft³ (kg/m³) from the nuclear gauge for each separate test. Obtain a moisture sample with a minimum weight of 500 g from each test site and place in cans for transportation to Area lab. Run moisture samples per AASHTO T265 to obtain oven dried moisture content of the samples. Using the nuclear gauge wet density and moisture content in lbs/ft³ (kg/m³), along with the results (percent moisture) of the laboratory oven dried moisture tests, Area Materials personnel will determine an individual moisture correlation for each of the four separate density tests, and will then average the individual values to obtain an overall moisture correlation. Sound engineering judgment should be utilized in the averaging process. If one of the individual moisture correlation values is significantly different from the other values, it should not be included in the averaging process to determine the overall moisture correlation. After the moisture correlation has been determined, Area Materials personnel will report the value in writing, with a copy sent to the Materials and Tests Engineer. Data/Calculations used in determining the moisture correlation are to be placed in the project file at the Area office.

Note 8: Area Materials personnel will issue a temporary moisture correlation, if needed, based on gauge wet density and moisture content along with results from field dried moisture samples until oven dried results are available.

9. Procedure

- 9.1. Density of asphalt base and pavement layers determined by nuclear gauge readings will be correlated to density of core specimens obtained from the layer as determined by AASHTO T-166. Four core specimens from the layer being tested

will be required for density curve correlations. The density correlation will be determined by establishing the difference between the average gauge density readings and the average bituminous core densities. If the average gauge wet density lbs/ft^3 (kg/m^3) is higher than the average bituminous core density lbs/ft^3 (kg/m^3) the correlation will be negative. If the average gauge wet density lbs/ft^3 (kg/m^3) is lower than the average bituminous core density lbs/ft^3 (kg/m^3) the correlation will be positive.

Example: Average gauge wet density 130.0 lbs/ft^3 (2028.4 kg/m^3) average bituminous core density 137.5 lbs/ft^3 (2145.5 kg/m^3) equals a plus 7.5 lbs/ft^3 (117.1 kg/m^3) correlation.

Note 9: The density correlation shall be added to or subtracted from the nuclear gauge wet density reading.