METHODS OF SAMPLING AND TESTING
MT 212-20
DETERMINATION OF MOISTURE AND DENSITY OF IN-PLACE MATERIALS
(*Modified AASHTO T 310 and T 355*)

1 Scope

1.1 This test method describes the procedures for determining the moisture and/or density of in-place materials, either in the natural state or after compaction, by the use of nuclear density/moisture gauge.

1.2 Alternatively, moisture may be determined in the laboratory by AASHTO T 265, Laboratory Determination of Moisture Content of Soils.

2 Referenced Documents

AASHTO
T 265 Laboratory Determination of Moisture Content of Soils
T 310 In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods
T 355 In-Place Density of Asphalt Mixtures by Nuclear Methods

MT Materials Manual
MT 210 Moisture-Density Relations of Soils Using A 5.5 Lb Rammer and a 12 In Drop
MT 230 Moisture-Density Relations of Soils Using A 10 Lb Rammer and a 18 In Drop

3 Apparatus

3.1 *Nuclear moisture/density gauge* containing radioactive sources, electronics and rechargeable batteries

3.2 *Standard Count Reference Block*

3.3 *AC Charger 115v/60Hz and DC Adapter 12v negative ground*

3.4 *Transport case* designed and labeled for each specific gauge

3.5 *Scraper Plate/Drill Rod Guide*

3.6 *Drill Rod and Drill Rod Extractor*

3.7 *Operators Manual and Gauge Booklet*

3.8 *Sieve*, 30 mesh for seating sand

3.9 *Thermoluminescent Dosimeter (TLD) Badge*

4 Calibration

The nuclear moisture/density gauges are calibrated by the MDT Materials Bureau for testing density of PCC and AC pavements. The gauges are also calibrated for both density and moisture of most soils and soil aggregate mixtures. The calibrations are stored electronically within the gauge.

5 Operational Considerations

5.1 A manufacturer's instructional manual is furnished with each nuclear device and must be consulted for operational procedures. These procedures vary between gauges and must be followed carefully.

5.2 Nuclear gauges shall **only be distributed** to personnel who have received the required 8 hour radiation safety and nuclear gauge operation course.

5.2.1 Gauge operators must attend a 2 to 4 hour refresher course at intervals not to exceed three (3) years. This training will be provided by MDT.

5.2.2 District Materials Supervisors must ensure that each gauge operator has completed an approved operator training course, that their card is up to date and in their possession, and that a radiation monitoring device (TLD Badge) is properly utilized when handling nuclear gauges.

5.3 Gauge operators should be very familiar with the Operator's Instruction Manual.

5.4 Gauge operators should always be aware of battery charge status and follow battery care instructions in Operator's Manual.

5.5 The gauge electronics must be turned on to warm up for a minimum of 15 minutes before taking the daily standard count or testing. Leave the power on all day during testing.

5.6 The Nuclear Gauge Transport form shall be kept with the nuclear gauge at all times. When transporting a gauge, the certification shall be filled out, visible and within reach of the driver.

5.7 Additional Operational Considerations and Radiation Safety are provided in the Appendix.

6 Standardization

6.1 Standard counts shall be taken and recorded each day that gauges are put into use and should be taken in the same environment as the actual measurement counts (i.e., at the construction site). The standardization should be performed with the gauge at least 10 m (30 ft) away from other nuclear density/moisture gauges and clear of large masses of water or other items that may affect the reference count rates.

6.2 If the daily standard counts are more than 1% for density or 2% for moisture from the average of the previous four counts, procedures should be thoroughly examined and the counts taken again. If these counts also fail, problems with the gauge or procedure are indicated and the appropriate District or Area Laboratory should be contacted.

7 Stability Test

7.1 A Stability Test should be performed whenever the accuracy of the gauge is in doubt.

7.2 A Stability Test consists of 20, one-minute Standard Counts.

7.3 Calculations (Using Actual Gauge Readings)

7.3.1 Determine the Average Reading (AVG)

$$AVG = \frac{\sum_1^N X}{N}$$

Where:
AVG = Average
X = Reading
N = number of readings

7.3.2 Calculate the Standard Deviation (SD)

$$SD = \sqrt{\frac{\sum_1^N (X - AVG)^2}{N}}$$

Where:
SD = Standard Deviation
X = Reading
N = number of readings

7.3.3 Calculate the Stability Ratio

$$Stability\ Ratio = \frac{SD}{\sqrt{AVG}}$$

7.4 If the ratio falls outside of the indicated ranges, procedures should be checked and the stability test taken again. If another failure occurs, contact the appropriate District or Area Lab.

PASSING RATIOS

Moisture	***Density***
0.18-0.35	0.18-0.35

8 Procedure

8.1 *Soil and Soil-Aggregate (Direct Transmission Method)*

8.1.1 Follow AASHTO T 310 Sections 9.1 – 9.3 and 9.5, collecting at least two (2) readings. Rotate the gauge 90 or 180 degrees, pivoting it around the source rod. The final result will be the average of all the readings.

8.1.2 Native fines or fine sand used to fill the voids and smooth the surface should be minus 30 mesh material screened from the material that is being compacted and dried to a constant mass.

8.2 *Asphalt Mixtures*

8.2.1 Follow AASHTO T 355 Section 9

8.2.2 Native fines or fine sand used to fill the voids and smooth the surface should be minus 30 mesh material screened from the material that is being compacted and dried to a constant mass.

9 Calculations

9.1 Use the appropriate Compaction Form for recording field determinations with Nuclear Devices.

9.2 Wet density, dry density, and moisture can be read directly from the gauge scales in pounds per cubic foot (lb/ft³). Percent moisture can also be read directly from the gauge.

9.3 Percent Compaction Calculation

$$\%\ Compaction = \frac{Field\ Dry\ Density\ (\frac{lb}{ft3})}{Proctor\ Dry\ Density}\ X\ 100$$

Note 1 – Proctor Dry Density from MT 210 or MT 230.

9.4 Compare field moisture to optimum moisture from the Proctor determination.

9.5 Record percent moisture and density readings to the nearest whole percent.

APPENDIX

A.1 Radiation Safety

A.1.1 Each nuclear gauge operator must wear a TLD badge attached to the front of his/her clothing or belt at waist level. The District Materials Supervisors issue these badges.

Note 2 – A TLD badge is a device that monitors a person's potential exposure to radiation.

A.1.1.1 These TLD badges must not be transferred from one operator to another.

A.1.1.2 When not in use, TLD badges should be stored at least 30 feet from nuclear gauges, out of direct sunlight, and away from excessive heat or dampness. ***Badges left near gauges are especially susceptible to unfounded high readings***.

A.1.1.3 Whenever a TLD badge has a high reading, the individual to whom the badge was issued will be notified and must fill out a report and submit it to the Materials Bureau within five days. It is important that all facts and details be presented accurately and conscientiously including diagrams, distances and times. Statements from supervisors and witnesses are also valuable.

A.1.1.4 The District Materials Supervisor will keep an up-to-date record consisting of the individual's name, the date the badge was issued, the serial number of the gauge they are using, and the project to which the gauge is assigned. This information, along with the TLD badges will be mailed to the Materials Bureau within ten days after the end of the quarter.

A.1.2 The leak testing of all nuclear gauges will be performed by personnel in the Materials Bureau or other individuals designated by the Radiation Safety Officer to perform such tests. An up-to-date record of the results of these tests shall also be maintained by the Materials Bureau.

A.2 Transportation

A.2.1 The nuclear gauges require careful handling. The vehicle in which they are transported should be capable of keeping them dry and provide complete security from unauthorized personnel. It should also be equipped with a carrying rack to which the instrument cases can be strapped and locked.

A.3 Storage

A.3.1 Storage areas should be locked and posted with radiation caution signs.

A.3.2 When the equipment is not being used, it should be stored in a separate dry room or garage. The temperature in the storage area should be above freezing and the batteries in the device should be fully charged. Never store a device in an area where personnel are working or will be working. Radiation caution signs shall be posted at the entrance door of any storage area.

A.3.3 Radiation levels surrounding the storage area shall not exceed two (2) millirems per hour. To help ensure low radiation levels outside the storage area, a gauge should be stored as near the center of the room as practical. Gauges should not be stored above, below or adjacent to a work area. The best way to assure radiation safety is to limit the number of gauges in a storage area. The largest number of gauges to be stored in one area is determined by the outside radiation level which shall not exceed 2 millirems per hour. The Materials Bureau in Helena will check the outside area to see if the radiation levels are acceptable.

A.3.4 Store the gauge fully charged. Battery charging during storage is not necessary but gauges should be given a full charge prior to initial use at the beginning of the construction season.

A.4 Maintenance

A.4.1 The Materials Bureau should be notified immediately when any breakdowns occur. It will be decided at that time whether the gauge should be sent to the Materials Bureau for repairs.

A.4.2 Clean and maintain the gauge regularly as recommended in the Operator's Manual.