
Standard Method of Test for In-Place Density of Asphalt Mixtures by Nuclear Methods

AASHTO Designation: T 355-22¹

Technically Revised: 2022

Editorially Revised: 2022

Technical Subcommittee: 2c, Asphalt–Aggregate Mixtures



**American Association of State Highway and Transportation Officials
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1. SCOPE

- 1.1. This test method describes the procedure for determining the in-place density of asphalt mixtures by use of nuclear gauge. The density of the material is determined by the backscatter/air-gap ratio method.
- 1.2. *Density*—The total density of asphalt mixtures is determined by the attenuation of gamma radiation where the source and detector(s) remain on the surface (backscatter method).
 - 1.2.1. The density in mass per unit volume of the material under test is determined by comparing the detected rate of gamma radiation with previously established calibration data.
- 1.3. *SI Units*—the values stated in SI units are to be regarded as the standard. The inch-pound equivalents may be approximate. It is common practice in the engineering profession to concurrently use pounds to represent both a unit of mass (lbm) and of force (lbf). This implicitly combines two systems of units, that is, the absolute system and the gravitational system.
 - 1.3.1. In the U.S. Customary units system, the pound (lbf) represents a unit of force (weight). However, the use of balances or scales recording pounds of mass (lbm) or recording density (lbm/ft³) should not be regarded as nonconformance with this standard.
- 1.4. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* See Section 6, Hazards.
- 1.5. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

- 2.1. AASHTO Standards:
 - [R 18](#), Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories

- [T 166](#), Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
- [T 191](#), Density of Soil In-Place by the Sand-Cone Method
- [T 209](#), Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures
- [T 331](#), Bulk Specific Gravity (G_{mb}) and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method

2.2. *ASTM Standards:*

- [D2216](#), Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- [D2937](#), Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
- [D7013/D7013M](#), Standard Guide for Calibration Facility Setup for Nuclear Surface Gauges

3. SIGNIFICANCE

- 3.1. This test method is useful as a rapid, nondestructive technique for the determination of the in-place density of asphalt mixtures.
- 3.2. This test method is used for quality control and acceptance testing of compacted asphalt mixtures for construction and for research and development.
- 3.3. *Density*—The fundamental assumptions inherent in the methods are that Compton scattering is the dominant interaction and that the material under test is homogeneous.
- 3.3.1. Test results may be affected by chemical composition, sample heterogeneity, and to a lesser degree, material density and the surface texture of the material being tested.
- 3.4. The test results can be used to establish the optimum rolling effort and evaluate the job mix formula for in-place properties. The nondestructive nature allows for repetitive measurements at a single test location and statistical analysis of the results.

Note 1—For in-place density results, correlation with cores is recommended (see Appendix X1).

4. INTERFERENCES

4.1. *In-Place Density Interferences:*

- 4.1.1. The chemical composition of the sample may affect the measurement, and adjustments may be necessary.
- 4.1.2. The gauge is more sensitive to the density of the material in close proximity to the surface.
Note 2—The nuclear gauge density measurements are somewhat biased to the surface layers of the material being tested. This method is more sensitive to the material within the first several inches from the surface.
- 4.1.3. Other radioactive sources must not be within 10 m (30 ft) of the gauge in operation.
- 4.1.4. Large objects must be at least 3 m (10 ft) away.
- 4.1.5. Use the gauge manufacturer's correction procedure when the gauge will be closer than 600 mm (24 in.) to any vertical mass, or less than 300 mm (12 in.) from a vertical pavement edge.

5. APPARATUS

- 5.1. *Nuclear Density Gauge (Either Density/Moisture or Density Gauge)*—While exact details of construction of the gauge may vary, the system consists of the following:
 - 5.1.1. *Instruction Manual*—For the specific make and model of gauge.
 - 5.1.2. *Radiation Source*—A sealed source of high-energy gamma radiation such as cesium or radium.
 - 5.1.3. *Gamma Detector*—Any type of gamma detector such as a Geiger-Mueller tube(s).
- 5.2. *Reference Standard*—A block of material used for checking gauge operations, for correcting source decay, and to establish conditions for a reproducible reference count rate.
- 5.3. *Site Preparation Device*—A plate, straightedge, or other suitable leveling tool.
- 5.4. *Transport Case*—For properly shipping and housing the gauge and tools.
- 5.5. *Filler Material*—Fine-graded sand from the source used to produce the asphalt pavement or other acceptable materials.
- 5.6. *Radioactive materials information and calibration packet containing:*
 - 5.6.1. Daily standard count log;
 - 5.6.2. Factory and laboratory calibration data sheet;
 - 5.6.3. Leak test certificate;
 - 5.6.4. Shipper's declaration for dangerous goods;
 - 5.6.5. Procedure memo for storing, transporting, and handling nuclear testing equipment; and
 - 5.6.6. Other radioactive materials documentation as required by local regulatory requirements.

6. HAZARDS

- 6.1. The gauge utilizes radioactive materials that may be hazardous to the health of the users unless proper precautions are taken. Users of the gauge must become familiar with applicable safety procedures and government regulations.
- 6.2. Effective user instructions together with routine safety procedures, such as source leak tests, recording and evaluation of film badge data, etc., are a recommended part of the operation and storage of this gauge.

7. CALIBRATION

- 7.1. Calibration of the gauge will be in accordance with Annexes A and B (if applicable). (See also [ASTM D7013/D7013M.](#))

8. STANDARDIZATION

- 8.1. All nuclear density gauges are subject to long-term aging of the radioactive sources, detectors, and electronic systems, which may change the relationship between count rates and the material density. To offset this aging, gauges are calibrated as a ratio of the measurement count rate to a count rate made on a reference standard or to an air-gap count (for the backscatter/air-gap ratio method). Take the reference count rate in the same or higher order of magnitude than the range of measurement count rates over the useful range of the gauge.
- 8.2. Standardization of the gauge on the reference standard is required at the start of each day's use and retain a permanent record of these data. Take standard counts in the same environmental conditions as the actual measurement counts. Perform the standardization with the gauge at least 10 m (30 ft) away from other radioactive sources and clear of large masses or other items which may affect the reference count rates.
- 8.2.1. Turn on the gauge and allow for stabilization according to the manufacturer's recommendations. If the gauge is to be used either continuously or intermittently during the day, it is best to leave it in the "power on" condition to prevent having to repeat the stabilization (refer to manufacturer recommendations). This will provide more stable, consistent results.
- 8.2.2. Using the reference standard, take at least four repetitive readings at the normal measurement period and obtain the mean. If available on the gauge, one measurement of four or more times the normal period is acceptable. This constitutes one standardization check.
- Use the procedure recommended by the gauge manufacturer for determining compliance with the gauge calibration curves. Without specific recommendations from the gauge manufacturer, use the procedure in Section 8.2.3.
- 8.2.3. If the mean of the four repetitive readings is outside the limits set by Equation 1, repeat the standardization check. If the second standardization check satisfies Equation 1, the gauge is considered in satisfactory operating condition. If the second standardization check does not satisfy Equation 1, check and verify the gauge according to Sections A1.8 and B1.5. If the verification shows that there is no significant change in the calibration curve, establish a new reference standard count, N_o . If the verification check shows that there is a significant difference in the calibration curve, repair and recalibrate the gauge.

$$N_s = N_o \pm 1.96\sqrt{(N_o / F)} \quad (1)$$

where:

N_s = value of current standardization count,

N_o = average of the past four values of N_s taken for prior usage, and

F = factory pre-scale factor (contact gauge manufacturer for the factor).

9. PROCEDURE

- 9.1. Select a relatively smooth and flat test location where the gauge will be at least 3 m (10 ft) away from any large objects. Follow the gauge manufacturer's correction procedures when closer than 600 mm (24 in.) to a vertical mass or less than 300 mm (12 in.) from a vertical pavement edge.
- 9.2. *Prepare the test site in the following manner:*
- 9.2.1. Maintain maximum contact between the base of the gauge and the surface of the material under test. Use filler material to fill surface voids. Spread a small amount of filler material over the test site surface and distribute it evenly. Strike off the surface with a straightedge (such as a lathe or flat-bar steel) to remove excess material.