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Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)[1]

This standard is issued under the fixed designation D6938; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method describes the procedures for measuring in-place density and moisture of soil and soil-aggregate by use of nuclear ~~equipment.~~ equipment (hereafter referred to as "gauge"). The density of the material may be measured by direct transmission, backscatter, or backscatter/air-gap ratio methods. Measurements for water (moisture) content are taken at the surface in backscatter mode regardless of the mode being used for density. ~~It is the intent of this subcommittee that this standard replace D2922 and D3017.~~

1.1.1 For limitations see Section 5 on Interferences.

1.2 The total or wet density of soil and soil-aggregate is measured by the attenuation of gamma radiation where, in direct transmission, the source is placed at a known depth up to 300 mm (12 in.) and the detector(s) remains on the surface (some gauges may reverse this orientation); or in backscatter or backscatter/air-gap the source and detector(s) both remain on the surface.

1.2.1 The density of the test sample in mass per unit volume is calculated by comparing the detected rate of gamma radiation with previously established calibration data.

1.2.2 The dry density of the test sample is obtained by subtracting the water mass per unit volume from the test sample wet density (Section 11). Most gauges display this value directly.

1.3 The gauge is calibrated to read the water mass per unit volume of soil or soil-aggregate. When divided by the density of water and then multiplied by 100, the water mass per unit volume is equivalent to the volumetric water content. The water mass per unit volume is determined by the thermalizing or slowing of fast neutrons by hydrogen, a component of water. The neutron source and the thermal neutron detector are both located at the surface of the material being tested. The water content most prevalent in engineering and construction activities is known as the gravimetric water content, w, and is the ratio of the mass of the water in pore spaces to the total mass of solids, expressed as a percentage.

1.4 Two alternative procedures are provided.

1.4.1 *Procedure A* describes the direct transmission method in which the probe extends through the base of the gauge into a pre-formed hole to a desired depth. The direct transmission is the preferred method.

1.4.2 *Procedure B* involves the use of a dedicated backscatter gauge or the probe in the backscatter position. This places the gamma and neutron sources and the detectors in the same plane.

1.4.3 Mark the test area to allow the placement of the gauge over the test site and to align the probe to the hole.

1.5 *SI Units*—The values stated in SI units are to be regarded as the standard. The values in inch-pound units (ft – lb units) are provided for information only.

1.6 All observed and calculated values shall conform to the guide for significant digits and rounding established in Practice D6026.

1.6.1 The procedures used to specify how data are collected, recorded, and calculated in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that should generally be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis methods for engineering design.

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

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*A Summary of Changes section appears at the end of this standard

1.7 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids
D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))
D1556 Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))
D2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4253 Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
D4254 Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
D4643 Test Method for Determination of Water Content of Soil and Rock by Microwave Oven Heating
D4718 Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
D4944 Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester
D4959 Test Method for Determination of Water Content of Soil By Direct Heating
D6026 Practice for Using Significant Digits in Geotechnical Data
D7013 Guide for Nuclear Surface Moisture and Density Gauge Calibration Facility Setup
D7759 Guide for Nuclear Surface Moisture and Density Gauge Calibration

3. Terminology

3.1 ~~*Definitions:*~~ *Definitions*—See Terminology D653 for general definitions.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *nuclear gauge*—a device containing one or more radioactive sources used to measure certain properties of soil and soil-aggregates.

~~3.2.2 *wet density*—same as bulk density (as defined in Terminology D653); the total mass (solids plus water) per total volume of soil or soil-aggregate.~~

~~3.2.3 *dry density*—same as density of dry soil or rock (as defined in Terminology D653); the mass of solid particles per the total volume of soil or soil-aggregate.~~

3.2.2 *gamma (radiation) source*—a sealed source of radioactive material that emits gamma radiation as it decays.

3.2.3 *neutron (radiation) source*—a sealed source of radioactive material that emits neutron radiation as it decays.

3.2.4 *Compton scattering*—the interaction between a gamma ray (photon) and an orbital electron where the gamma ray loses energy and rebounds in a different direction.

3.2.5 *detector*—a device to detect and measure radiation.

3.2.6 *gravimetric water content*—same as water content (as defined in Terminology D653), a nomenclature used in some scientific fields to differentiate it from volumetric water content.

3.2.7 *thermalization*—the process of "slowing down" fast neutrons by collisions with light-weight atoms, such as hydrogen.

~~3.2.9 *water content*—the ratio of the mass of water contained in the pore spaces of soil or soil-aggregate, to the solid mass of particles in that material, expressed as a percentage (*this is sometimes referred to in some scientific fields as gravimetric water content to differentiate it from volumetric water content*).~~

3.2.8 *volumetric water content*—the volume of water as a percent of the total volume of soil or rock material.

3.2.9 *test count, n*—the measured output of a detector for a specific type of radiation for a given test.

3.2.10 *prepared blocks*—blocks prepared of soil, solid rock, concrete, and engineered materials, that have characteristics of various degrees of reproducible uniformity.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

4. Significance and Use

4.1 The test method described is useful as a rapid, nondestructive technique for in-place measurements of wet density and water content of soil and soil-aggregate and the determination of dry density.

4.2 The test method is used for quality control and acceptance testing of compacted soil and soil-aggregate mixtures as used in construction and also for research and development. The nondestructive nature allows repetitive measurements at a single test location and statistical analysis of the results.

4.3 *Density*—The fundamental assumptions inherent in the methods are that Compton scattering is the dominant interaction and that the material is homogeneous.

4.4 *Water Content*—The fundamental assumptions inherent in the test method are that the hydrogen ions present in the soil or soil-aggregate are in the form of water as defined by the water content derived from Test Methods D2216, and that the material is homogeneous. (See 5.2)

NOTE 1—The quality of the result produced by this standard test method is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection, and the like. Users of this standard are cautioned that compliance with Practice D3740 does not in itself ensure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

5. Interferences

5.1 *In-Place Density Interferences*

5.1.1 Measurements may be affected by the chemical composition of the material being tested.

5.1.2 Measurements may be affected by non-homogeneous soils and surface texture (see 10.2). Excessive voids in the prepared test surface beneath the gauge can cause density measurements that are lower than the actual soil density. Excessive use of fill material to compensate for these voids may likewise cause biased density measurements, or biased water content measurements, or both.

5.1.3 Measurements in the Backscatter Mode are influenced more by the density and water content of the material in proximity to the surface.

5.1.4 Measurements in the Direct Transmission mode are an average of the density from the bottom of the probe in the soil or soil aggregate back up to the surface of the gauge.

5.1.5 Gravel particles or large voids in the source-detector path may cause higher or lower density measurments. Where lack of uniformity in the soil due to layering, aggregate or voids is suspected, the test site should be excavated and visually examined to determine whether the test material is representative of the in situ material in general and whether an oversize correction is required in accordance with Practice D4718~~D4718.~~.

5.1.6 Oversize particles or large voids in the source-detector path may cause higher or lower density measurements. Where lack of uniformity in the soil due to layering, aggregate or voids is suspected, the test site should be excavated and visually examined to determine if the test material is representative of the in situ material in general and if an oversize correction is required in accordance with Practice D4718.

5.1.7 The measured volume is approximately 0.0028 m^3 (0.10 ft^3) for the Backscatter Mode and 0.0057 m^3 (0.20 ft^3) for the Direct Transmission Mode when the test depth is 150 mm (6 in.). The actual measured volume is indeterminate and varies with the apparatus and the density of the material.

5.1.8 Other radioactive sources must not be within 9 m (30 ft) of equipment in operation.

5.2 *In-Place Water (Moisture) Content Interferences*

5.2.1 The chemical composition of the material being tested can affect the measurement and adjustments may be necessary (see Section 10.6). Hydrogen in forms other than water and carbon will cause measurements in excess of the true value. Some chemical elements such as boron, chlorine, and cadmium will cause measurements lower than the true value.

5.2.2 The water content measured by this test method is not necessarily the average water content within the volume of the sample involved in the measurement. Since this measurement is by backscatter in all cases, the value is biased by the water content of the material closest to the surface. The volume of soil and soil-aggregate represented in the measurement is indeterminate and will vary with the water content of the material. In general, the greater the water content of the material, the smaller the volume involved in the measurement. Approximately 50 % of the typical measurement results from the water content of the upper 50 to 75 mm (2 to 3 in.).

5.2.3 Other neutron sources must not be within 9 m (30 ft) of equipment in operation.

6. Apparatus

6.1 *Nuclear Density / Moisture Gauge*—While exact details of construction of the apparatus may vary, the system shall consist of:

6.1.1 *Gamma Source*—A sealed source of high-energy gamma radiation such as cesium or radium.

6.1.2 *Gamma Detector*—Any type of gamma detector such as a Geiger-Mueller tube(s).

6.1.3 *Fast Neutron Source*—A sealed mixture of a radioactive material such as americium, radium and a target material such as beryllium, or a neutron emitter such as californium-252.

6.1.4 *Slow Neutron Detector*—Any type of slow neutron detector such as boron trifluoride or helium-3 proportional counter.

6.2 *Reference Standard*—A block of material used for checking instrument operation, correction of source decay, and to establish conditions for a reproducible reference count rate.

6.3 *Site Preparation Device*—A plate, straightedge, or other suitable leveling tool that may be used for planing the test site to the required smoothness, and in the Direct Transmission Method, guiding the drive pin to prepare a perpendicular hole.

6.4 *Drive Pin*—A pin of slightly larger diameter than the probe in the Direct Transmission Instrument used to prepare a hole in the test site for inserting the probe.

6.4.1 *Drive Pin Guide*—A fixture that keeps the drive pin perpendicular to the test site. Generally part of the site preparation device.

6.5 *Hammer*—Heavy enough to drive the pin to the required depth without undue distortion of the hole.

6.6 *Drive Pin Extractor*—A tool that may be used to remove the drive pin in a vertical direction so that the pin will not distort the hole in the extraction process.

6.7 *Slide Hammer,* with a drive pin attached, may also be used both to prepare a hole in the material to be tested and to extract the pin without distortion to the hole.

6.8 *Probe,* a slender, elongated device, part of the gauge, that is inserted into the soil under measurement by the gauge. This device may contain either a radioactive source, a radiation detection device, or both. Probes containing only a radioactive source are commonly referred to as "source rods."

7. Hazards

7.1 These gauges utilize radioactive materials that may be hazardous to the health of the users unless proper precautions are taken. Users of these gauges must become familiar with applicable safety procedures and government regulations.

7.2 Effective user instructions, together with routine safety procedures and knowledge of and compliance with Regulatory Requirements, are a mandatory part of the operation and storage of these gauges.

8. Calibration

8.1 Gauge calibration shall be performed in accordance with Guides D7013 and D7759.

9. Standardization

9.1 Nuclear moisture density gauges are subject to long-term aging of the radioactive sources, which may change the relationship between count rates and the material density and water content. To correct for this aging effect, 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).

9.2 Standardization of the gauge shall be performed at the start of each day's use, and a record of these data should be retained for the amount of time required to ensure compliance with either subsection 9.2.2 or 9.2.3, whichever is applicable. Perform the standardization with the gauge located at least 9 m (30 ft) away from other nuclear moisture density gauges and clear of large masses of water or other items which can affect the reference count rates.

9.2.1 Turn on the gauge and allow for stabilization according to the manufacturer's recommendations.

9.2.2 Using the reference standard, take a reading that is at least four times the duration of a normal measurement period (where a normal measurement period is typically one minute) to constitute one standardization check. Use the procedure recommended by the gauge manufacturer to establish the compliance of the standard measurement to the accepted range. Without specific recommendations from the gauge manufacturer, use the procedure in 9.2.3.

9.2.3 If the values of the current standardization counts are outside the limits set by Eq 1 and Eq 2, repeat the standardization check. If the second standardization check satisfies Eq 1 and Eq 2, the gauge is considered in satisfactory operating condition.

$$0.99(N_{dc})e^{\frac{-(ln(2))t}{T_{d(1/2)}}} \leq N_{d0} \leq 1.01(N_{dc})e^{\frac{-(ln(2))t}{T_{d(1/2)}}} \quad (1)$$

and

$$0.98(N_{mc})e^{\frac{-(ln(2))t}{T_{m(1/2)}}} \leq N_{m0} \leq 1.02(N_{mc})e^{\frac{-(ln(2))t}{T_{m(1/2)}}} \quad (2)$$

where:

$T_{d(1/2)}$ = the half-life of the isotope that is used for the density determination in the gauge. For example, for ^{137}Cs, the radioactive isotope most commonly used for density determination in these gauges, $T_{d(1/2)}$, is 11 023 days,

$T_{m(1/2)}$ = the half-life of the isotope that is used for the water content determination in the gauge. For example, for ^{241}Am, the radioactive isotope in Am:Be, the radioactive source most commonly used for water content determination in these gauges, $T_{m(1/2)}$, is 157 788 days,

N_{dc} = the density system standardization count acquired at the time of the last calibration or verification,
N_{mc} = the moisture system standardization count acquired at the time of the last calibration or verification,
N_{d0} = the current density system standardization count,
N_{m0} = the current moisture system standardization count,
t = the time that has elapsed between the current standardization test and the date of the last calibration or verification. The units selected for t, $T_{d(1/2)}$, and $T_{m(1/2)}$ should be consistent, that is, if $T_{d(1/2)}$ is expressed in days, then t should also be expressed in days,
$ln(2)$ = the natural logarithm of 2, which has a value of approximately 0.69315,
e = the inverse of the natural logarithm function, which has a value of approximately 2.71828.

9.2.4 If for any reason the measured density or moisture becomes suspect during the day's use, perform another standardization check.

9.3 *Example*—A nuclear gauge containing a ^{137}Cs source for density determination (half-life = 11 023 days) and an ^{241}Am:Be source for moisture determination (half-life = 157 788 days) is calibrated on March 1 of a specific year. At the time of calibration, the density standard count was 2800 counts per minute (prescaled), and the moisture standard count was 720 counts per minute (prescaled). According to Eq 1 and Eq 2 from Section 9.2.3, what is the allowed range of standard counts for November 1 of the same year?

9.3.1 For this example, a total of 245 days have elapsed between the date of calibration or verification (March 1) and the date of the gauge standardization (November 1). Therefore:

t = 245 days
$T_{d(1/2)}$ = 11 023 days
$T_{m(1/2)}$ = 157 788 days
N_{dc} = 2800 counts
N_{mc} = 720 counts

9.3.2 According to Eq 1, therefore, the lower limit for the density standard count taken on November 1, denoted by N_{d0}, is:

$$0.99(N_{dc})e^{\frac{-(ln(2))t}{T_{d(1/2)}}} = 0.99(2800)e^{\frac{-(ln(2))\cdot 245}{11\ 023}} = 2772e^{-0.01541} = 2730\ counts$$

9.3.3 Likewise, the upper limit for the density standard count taken on November 1, denoted by N_{d0}, is:

$$1.01(N_{dc})e^{\frac{-(ln(2))t}{T_{d(1/2)}}} = 1.01(2800)e^{\frac{-(ln(2))\cdot 245}{11\ 023}} = 2828e^{-0.01541} = 2785\ counts$$

9.3.4 Therefore, the density standard count acquired on November 1 should lie somewhere between 2730 and 2785 counts, or $2730 \leq N_{d0} \leq 2785$. According to Eq 2, the lower limit for the moisture standard count taken on November 1, denoted by N_{m0}, is:

$$0.98(N_{mc})e^{\frac{-(ln(2))t}{T_{m(1/2)}}} = 0.98(720)e^{\frac{-(ln(2))\cdot 245}{157\ 788}} = 706e^{-0.00108} = 705\ counts$$

9.3.5 Likewise, the upper limit for the moisture standard count taken on November 1, denoted by N_{d0}, is:

$$1.02(N_{mc})e^{\frac{-(ln(2))t}{T_{m(1/2)}}} = 1.02(720)e^{\frac{-(ln(2))\cdot 245}{157\ 788}} = 734e^{-0.00108} = 733\ counts$$

9.3.6 Therefore, the moisture standard count acquired on November 1 should lie somewhere between 705 and 733 counts, or $705 \leq N_{m0} \leq 733$.

10. Procedure

10.1 When possible, select a test location where the gauge will be placed at least 600 mm (24.0 in) away from any object sitting on or projecting above the surface of the test location, when the presence of this object has the potential to modify gauge response. Any time a measurement must be made at a specific location and the aforementioned clearance cannot be achieved, such as in a trench, follow the gauge manufacturer's correction procedure(s).

10.2 *Prepare the test site in the following manner:*

10.2.1 Remove all loose and disturbed material and additional material as necessary to expose the true surface of the material to be tested.

10.2.2 Prepare an area sufficient in size to accommodate the gauge by grading or scraping the area to a smooth condition so as to obtain maximum contact between the gauge and material being tested.

10.2.3 The depth of the maximum void beneath the gauge shall not exceed 3 mm (1⁄8 in.). Use ~~native fines~~ either native material that does not contain gravel or fine sand to fill the voids, and then smooth the surface with ~~a rigid straight edge~~the site preparation device or other suitable tool. The depth of the filler should not exceed approximately 3 mm (1⁄8 in.).

10.2.4 The placement of the gauge on the surface of the material to be tested is critical to accurate density measurements. The optimum condition is total contact between the bottom surface of the gauge and the surface of the material being tested. The total area filled should not exceed approximately 10 percent of the bottom area of the gauge.

10.3 Turn on and allow the gauge to stabilize (warm up) according to the manufacturer's recommendations (see Section 9.2.1).

10.4 Procedure A - *The Direct Transmission Procedure:*

10.4.1 Select a test location where the gauge in test position will be at least 150 mm (6 in.) away from any vertical projection.

10.4.2 Make a hole perpendicular to the prepared surface using either (*a*~~the rod guide and drive pin.~~) the drive pin guide, the guide pin extractor, a hammer, and drive pin, or (*b*) a slide hammer. The hole should be a minimum of 50 mm (2 in.) deeper than the desired measurement depth and of an alignment that insertion of the probe will not cause the gauge to tilt from the plane of the prepared area.

10.4.3 Mark the test area to allow the placement of the gauge over the test site and to align the probe to the hole. Follow the manufacturer's recommendations if applicable.

10.4.4 Remove the hole-forming device carefully to prevent the distortion of the hole, damage to the surface, or loose material to fall into the hole.

NOTE 2—Care must be taken in the preparation of the access hole in uniform cohesionless granular soils. Measurements can be affected by damage to the density of surrounding materials when forming the hole.

10.4.5 Place the gauge on the material to be tested, ensuring maximum surface contact as described previously in 10.2.4.

10.4.6 Lower the probe into the hole to the desired test depth. Pull the gauge gently toward the back, or detector end, so that the back side of the probe is in intimate contact with the side of the hole in the gamma measurement path.

NOTE 3—As a safety measure, it is recommended that a probe containing radioactive sources not be extended out of its shielded position prior to placing it into the test site. When possible, align the gauge so as to allow placing the probe directly into the test hole from the shielded position.

10.4.7 Keep all other radioactive sources at least 9 m (30 feet) away from the gauge to avoid any effect on the measurement.

10.4.8 If the gauge is so equipped, set the depth selector to the same depth as the probe.

10.4.9 Secure and record one or more one-minute density and water content readings. Read the in-place wet density directly or determine one by use of the calibration curve or table previously established.

10.4.10 Read the water content directly or determine the water content by use of the calibration curve or table previously established.

10.5 Procedure B *-The Backscatter or Backscatter/Air-Gap Ratio Procedure:*

10.5.1 Seat the gauge firmly (see Note 2).

10.5.2 Keep all other radioactive sources at least 9 m (30 ft) away from the gauge to avoid affecting the measurement.

10.5.3 Set the gauge into the Backscatter (BS) position.

10.5.4 Secure and record one or more set(s) of one-minute density and water content readings. When using the backscatter/air-gap ratio mode, follow the manufacturer's instructions regarding gauge setup. Take the same number of readings for the normal measurement period in the air-gap position as in the standard backscatter position. Calculate the air-gap ratio by dividing the counts per minute obtained in the air-gap position by the counts per minute obtained in the standard position. Many gauges have built-in provisions for automatically calculating the air-gap ratio and wet density.

10.5.5 Read the in-place wet density or determine one by use of the calibration curve or table previously established.

10.5.6 Read the water content or determine one by use of the calibration curve or previously established table (see Section 10.6).

NOTE 4—Gauge measurements acquired using either Procedure A or Procedure B yield both density and water content values for the material under test. It is good practice to record gauge density and water counts corresponding to the density and water values at the time of measurement in the event that data recording errors or improper probe depth errors are of concern.

10.6 *Water Content Correction and Oversize Particle Correction*

10.6.1 For proper use of the gauge and accurate values of both water content and dry density, both of these corrections need to be made when applicable.

Prior to using the gauge-derived water content on any new material, the value should be verified by comparison to another ASTM method such as Test Methods D2216, D4643, D4944, or D4959. As part of a user developed procedure, occasional samples should be taken from beneath the gauge and comparison testing done to confirm gauge-derived water content values. All gauge manufacturers have a procedure for correcting the gauge-derived water content values.

10.6.2 When oversize particles are present, the gauge can be rotated about the axis of the probe to obtain additional readings as a check. When there is any uncertainty as to the presence of these particles it is advisable to sample the material beneath the gauge to verify the presence and the relative proportion of the oversize particles. A rock correction can then be made for both water content and wet density by the method in Practice D4718.

10.6.3 When sampling for water content correction or oversize particle correction, the sample should be taken from a zone directly under the gauge. The size of the zone is approximately 200 mm (8 in.) in diameter and a depth equal to the depth setting of the probe when using the direct transmission mode; or approximately 75 mm (3 in.) in depth when using the backscatter mode.

11. Calculation of Results

11.1 *Determine the Wet Density:*

11.1.1 On most gauges read the value directly in kg/m^3 (lbm/ft^3). If the density reading is in "counts", determine the in-place wet density by use of this reading and the previously established calibration curve or table for density.

11.1.2 Record the density to the nearest 1 kg/m^3 (0.1 lbm/ft^3).