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Standard Guide for Nuclear Surface Moisture and Density Gauge Calibration Facility Setup[1]

This standard is issued under the fixed designation D7013; 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.

ε[1] NOTE—References to ASTM standards in Section 6.1 were editorially updated in March 2010.

1. Scope

1.1 This guide outlines procedures for setup of nuclear moisture density gauge in shielded, Method A, and unshielded, Method B, configurations.

1.2 This guide does not attempt to describe the calibration techniques or methods. It is assumed that this guide will be used by persons familiar with the operations of the gauge and in performing proper calibration, service and maintenance.

1.3 This guide does not attempt to address maintenance or service procedures related to the gauge.

1.4 *This guide 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 guide to establish appropriate safety, and health practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document has been approved through ASTM consensus process.*

1.6 *All observed and calculated values shall conform to the guidelines for significant digits and rounding established in practice D6026.*

1.6.1 *The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy to which the data can be applied in the design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D6026 Practice for Using Significant Digits in Geotechnical Data

D6938 Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

3. Terminology

3.1 For common definitions of terms refer to Terminology D653

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *Unshielded Calibration bay*—An open area within a calibration facility where the closest wall is a minimum of 1 meter (3 ft.) from the spot in which the gauge is being calibrated.

3.2.2 *Shielded Calibration bay*—An enclosed area surrounded by concrete blocks or walls to protect the gauge being calibrated from outside influence and background radiation from all gauges in the facility.

3.2.3 *Shielded Storage Bay*—An enclosed area shielded by walls to maintain and control radiation background in the facility and to reduce influences from stored gauges.

4. Summary of Method

4.1 Nuclear moisture density gauges require proper calibration to ensure measurement repeatability between gauges. Since these gauges contain radioactive isotopes, influences from the surroundings and other gauges should be controlled during the calibration process. This guide provides procedures to facilities involved in calibration of one or more gauges in

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[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.

shielded and unshielded calibration bays. The goal of this guide is to insure proper gauge calibration and to reduce influences that would result in field measurement variability between gauges.

5. Significance and Use

5.1 Gauge calibration is conducted for the following purposes:

5.1.1 To ensure gauge measurement repeatability between gauges

5.1.2 To correct for electronic and mechanical changes over time

5.1.3 To adjust readings after major service to the gauge

5.2 To establish a proper calibration area for gauges

5.3 To reduce the chance of improper calibration

NOTE 1—The quality of the results produced by this standard 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/inspection/etc. Users of this standard are cautioned that compliance with practice D3740 does not in itself assure a means of evaluating some of those factors.

6. Apparatus

6.1 Calibration reference block(s) as per the requirements of Test Method D6938 with density certification from the block manufacturer

6.2 High density concrete blocks 9cm × 20 cm × 41 cm (3.5″ × 8″ × 16″) or cinder blocks 20 cm × 20 cm × 41 cm (8″ × 8″ × 16″) filled with sand or other fine aggregate materials for construction of bay walls

6.3 Lead sheet 1 to 6 mm (0.032 to 0.25 inches) thick for lining the bay walls. The exposed surfaces containing lead should be painted or covered

6.4 Plywood of minimum 1.3 cm (0.5″) thickness for securing lead sheets to the calibration bay walls.

7. Method A: Shielded Calibration Bay Setup

7.1 Set up a shielded calibration bay if more than one gauge is going to be calibrated simultaneously, and the space between gauges being calibrated is less than 10 meter (33 ft). If the gauge in storage bay is less than 7 meters (23 ft) from the area where the calibration is going to take place, or if the area where gauges are routinely serviced is less than 10 meters (33 ft) from the calibration area. Refer to the Appendix X1 for examples of shielded calibration bay configurations.

NOTE 2—Use Method B, if section 7.1 does not fit your calibration facility requirements.

7.1.1 Determine the number of bays required for calibration of nuclear gauges. This can be based on the number of gauges calibrated per year and can vary from one to several bays.

7.1.2 The bay inside dimensions should be established based on the bay walls being a minimum of 610 mm (24 inches) from the center of calibration blocks and lined with 1 mm (0.032 inches) of lead. Smaller inside dimensions can be used if lead sheets thicker than 6 mm (0.25 inch) are used on the walls. However, under no circumstances should the walls be less than 610 mm (24 inches) from center of the gauge.

NOTE 3—Depending on their design, some gauges may be less susceptible to wall effect. Lead sheets may not be required, if it is determined that the counts inside and outside the bay are equal and that the gauge is not affected by the walls surrounding the calibration bay.

7.1.3 The calibration bay wall thickness should be a minimum of 410 mm (16 inches) thick. The walls should be constructed using high-density concrete blocks or cinder blocks filled with sand or fine aggregate material. Stagger the blocks during wall construction to block gaps and to improve wall integrity.

7.1.4 The wall height should be 1.0 to 1.3 meters (40 to 50 inches)

7.1.5 Design and construct the bay such that the opening of the bay is not in direct line with the storage bay or the area where the gauges are serviced

7.1.6 Center the calibration reference block(s) in the bay

7.1.7 Once the bays are complete and the calibration blocks are setup, follow the procedures in section 9 and make adjustments, if necessary.

7.2 *Configuration of a Shielded Bay*

7.2.1 *Wall Influence Verification for Shielded Calibration Bay(s)*—The response to the surrounding walls can vary significantly for different gauge geometries. For accurate calibration, influence from the walls should be eliminated.

7.2.1.1 Place a gauge on a calibration reference block

7.2.1.2 Take two four minute counts, moisture and density, in Backscatter and 300 mm (12 inch) position and one four minute counts at all other gauge depths.

7.2.1.3 Move the calibration reference block(s) out of the bay, a minimum of 1 meter (3 ft) from any walls and 10 meter (33 ft) from any gauges.

7.2.1.4 Repeat step 7.2.1.2 with the same gauge

7.2.1.5 The difference between the counts in step 7.2.1.2 and 7.2.1.4 for all gauge depths should be less than ±1.0 %. Determine the difference by equation Eq 1 and record to 0.1 %

$$\%Difference = \left(\frac{Largest\ Count - Smallest\ Count}{Largest\ Count}\right) \times 100 \qquad (1)$$

7.2.1.6 If the difference in the counts are higher than the ± 1.0 % limit, increase the inside wall dimensions or the lead liner thickness and repeat the steps in 7.2.1.1-7.2.1.5.

7.2.1.7 Repeat this procedure for all model gauges.

7.2.2 *Reference Standard Count Verification in Shielded Calibration Bay(s)*—The size and geometry of gauges will have an effect on the accuracy of the standard counts. For accurate calibration, standard counts taken on top of calibration reference block(s) should closely match counts taken on the ground.

7.2.2.1 Place the gauge on its reference standard block on top of the calibration reference block which is to be used for gauge standardization.

7.2.2.2 Take a total of 20 minute standardization count. For example, average of 20 one minute counts, average of 5 four minute counts, etc.

7.2.2.3 Record the moisture and density count

7.2.2.4 Remove the calibration reference block from the calibration bay

7.2.2.5 Place the gauge on its reference standard block in safe position in the middle of the bay on the floor

7.2.2.6 Take a total of 20 minute standardization count

7.2.2.7 Record the moisture and density counts

7.2.2.8 Compare the counts in step 7.2.2.3-7.2.2.7. The difference in counts as calculated by equation 1 should be less than or equal to ± 2.0 % for moisture standard and ± 1.0 % for density standard.

7.2.2.9 If the differences exceed the limits given in 7.2.2.8, expand the bay dimensions, apply correction factors for the counts taken on top of the calibration reference block(s) or take the standard counts on the ground. It is important that this section is repeated for each gauge model.

7.2.3 *Between Bay Cross Talk Verification*—Sufficient shielding should be provided between adjacent shielded calibration bays in order to eliminate influence from each bay. Bays should be setup to eliminate influence from gauges being calibrated in adjacent bays.

7.2.3.1 Place one gauge in each bay. Place the gauges on their reference standard block in the safe position on top of the calibration reference block(s).

7.2.3.2 Take a total of 20 minute count with each gauge in each bay.

7.2.3.3 Record the counts for both moisture and density for both gauges

7.2.3.4 Remove one of the gauges from the bay and place it in the storage bay

7.2.3.5 With the second gauge still remaining in the calibration bay and without moving the gauge, take a second 20 minute standard count.

7.2.3.6 Record the moisture and density counts

7.2.3.7 Compare the average of the 20 minute counts in step 7.2.3.6 to counts for the same gauge in step 7.2.3.3.

7.2.3.8 The difference in the counts in step 7.2.3.7 should be less than or equal to ± 1.0 % for density and ±2.0 % for moisture.

7.2.3.9 If this difference is larger than the limits in 7.2.3.8, increase the wall thickness between the bays or add to the thickness of the lead sheet liners.

7.2.3.10 Repeat the steps of this section for each set of adjacent bays to verify that cross talk between bays has been eliminated

7.2.3.11 Repeat this section for each gauge model or conduct this test using gauges with plastic top shells and the largest radioactive sources.

NOTE 4—Do not use the calibration bay to store gauges. Increased number of gauges in one bay can affect the calibration accuracy of gauges in the adjacent bays.

7.2.4 Follow block manufacturers procedures to complete the gauge calibration

8. Shielded Storage Bay Setup

8.1 Setup a shielded storage bay if more than five gauges are routinely stored at a distance of 7 meters (23 ft) or less from the area where gauge calibration is to take place. If five or less gauges are routinely stored in the storage area, concrete walls are not necessary. However, gauges should be stored in their shipping cases, while calibrating other gauges. Refer to the Appendix X1 for examples of shielded storage bay configurations.

8.1.1 The storage bay should not be setup directly under or over the area where gauges are to be calibrated.

8.1.2 Stagger the blocks during wall construction to block gaps and to improve wall integrity.

8.1.3 If more than five gauges are routinely stored in the storage bay, build a wall made from high density concrete or cinder blocks filled with sand or fine aggregate material.

8.1.4 The wall thickness for the storage bay should be a minimum of 410 mm (16 inches). The wall should completely surround the area where the gauges are planned to be stored. If gauges are stored on shelves that are elevated from the floor, the height of the wall should be a minimum of 0.5 meter (20 inch) above the height of the shelves on which gauges are stored.

NOTE 5—Additional requirements might be necessary in order to meet State and Federal licensing regulations. These requirements might include, lockable doors to limit access and appropriate caution signs. Users should check their materials license requirements and check with their regulatory agency when building storage bays for nuclear gauges.

9. Method B: Configuration of an Unshielded Bay

9.1 The area where the gauges are stored and are being worked on should be at least 10 meters (33 ft) away from the area where the calibration reference block(s) are placed for calibration.

9.2 If more than 5 gauges are stored in the storage, either remove the extra gauges and place 20 meters (66 ft) away while calibrating the gauges or build a shielded storage bay according to Method A.

9.3 If more than one gauge is being calibrated simultaneously, place the calibration reference block(s) a minimum of 10 meters (33 ft) away from each other.

9.4 Follow block manufacturers procedures to complete the gauge calibration.

10. General Care

10.1 Clean calibration reference block(s) periodically using block manufacturers recommendations

10.2 Monitor the background readings in your calibration area. Backgrounds taken should not vary by more than ± 3.0 % from the average of the four previous background counts. If background counts have increased above the ± 3.0 % limit, identify the reason and make the appropriate adjustments by removing the source of extra background or adjusting the gauge calibration counts accordingly.

NOTE 6—Normal background counts in calibration facilities should not exceed 100 ± 30 counts per minute for each individual radioactive source. If higher background counts are measured, the calibration counts should be corrected.

11. Reporting

11.1 Report the following information:

11.1.1 Record the reference block(s) densities at all depths

11.1.2 Record the information collected in sections 7.2.1

11.1.3 Record the information collected in sections 7.2.2

11.1.4 Record the information collected in sections 7.2.3