



Designation: D4452/D4452M – 22

Standard Practice for X-Ray Radiography of Soil Samples¹

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1. Scope*

1.1 This practice covers the determination of the quality of soil samples in thin wall tubes or of extruded soil cores by X-ray radiography.

1.2 This practice enables the user to determine the effects of sampling and natural variations within samples as identified by the extent of the relative penetration of X-rays through soil samples.

1.3 This practice can be used to X-ray soil cores (or observe their features on a fluoroscope) in thin wall tubes or liners ranging from approximately 50 to 150 mm [2 to 6 in.] in diameter. X-rays of samples in the larger diameter tubes provide a radiograph of major features of soils and disturbances, such as large scale bending of edges of varved clays, shear planes, the presence of large concretions, silt and sand seams thicker than 6 mm [$\frac{1}{4}$ in.], large lumps of organic matter, and voids or other types of intrusions. X-rays of the smaller diameter cores provide higher resolution of soil features and disturbances, such as small concretions (3 mm [$\frac{1}{8}$ in.] diameter or larger), solution channels, slight bending of edges of varved clays, thin silt or sand seams, narrow solution channels, plant root structures, and organic matter. The X-raying of samples in thin wall tubes or liners requires minimal preparation.

1.4 Greater detail and resolution of various features of the soil can be obtained by X-raying extruded soil cores, as compared to samples in metal tubes. The method used for X-raying soil cores is the same as that for tubes and liners, except that extruded cores have to be handled with extreme care and have to be placed in sample troughs (similar to Fig. 2) before X-raying. This practice should be used only when natural water content or other intact soil characteristics are irrelevant to the end use of the sample.

1.4.1 Often it is necessary to obtain greater resolution of features to determine the propriety of sampling methods, the representative nature of soil samples, or anomalies in soils.

¹ This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and are the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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This practice requires that either duplicate samples be obtained or already tested specimens be X-rayed.

1.5 This practice can only be used to its fullest extent after considerable experience is obtained through many detailed comparisons between the X-ray image and the sample X-rayed.

1.6 *Units*—The values stated in either SI units or inch-pound units [presented in brackets] are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with standard.

1.7 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice 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 means only that the document has been approved through the ASTM consensus process.

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

1.8.1 For purposes of comparing, a measured or calculated value(s) with specified limits, the measured or calculated value(s) shall be rounded to the nearest decimal or significant digits in the specified limits.

1.8.2 The procedures used to specify how data are collected/recorded or calculated, in this standard are regarded as the industry standard. In addition, they are representative of the signification digits that generally should 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.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the*

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

responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use. For specific precaution statements, see Section 7.

1.10 This international standard was developed in accordance with internationally recognized principles on standardization established in the *Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee*.

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 and Data Records in Geotechnical Data

E7 Terminology Relating to Metallography

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common technical terms used in this standard relating to soil samples, refer to Terminology **D653**.

3.1.2 For definitions of common technical terms used in this standard relating to X-ray Radiography, refer to Definitions **E7**.

4. Summary of Practice

4.1 This standard practice involves the preparation of soil core samples and use of X-ray technology to produce images of soil core samples often contained in metallic tubes or extruded. These images provide insight into the quality of the sample, the type of material contained in the sample and can help guide decision making process when selecting samples or sections of a sample for laboratory test specimens.

5. Significance and Use

5.1 Many geotechnical tests require the utilization of intact, representative samples of soil. The quality of these samples depends on many factors. Many of the samples obtained by intact sampling methods have inherent anomalies. Sampling procedures cause disturbances of varying types and intensities. These anomalies and disturbances, however, are not always readily detectable by visual inspection of the intact samples before or after testing. Often test results would be enhanced if the presence and the extent of these anomalies and disturbances are known before testing or before destruction of the sample by testing. Such determinations assist the user in detecting flaws in sampling methods, the presence of natural or induced shear planes, and the presence of natural intrusions, such as gravels

or shells at critical regions in the samples, the presence of sand and silt seams, and the intensity of disturbances caused by sampling.

5.2 X-ray radiography provides the user with a picture of the internal massive structure of the soil sample, regardless of whether the soil is X-rayed within or without the sampling tube. X-ray radiography assists the user in identifying the following:

5.2.1 Appropriateness of sampling methods used.

5.2.2 Effects of sampling in terms of the disturbances caused by the turning of the edges of various thin layers in varved soils, large disturbances caused in soft soils, shear planes induced by sampling, or extrusion, or both, effects of overdriving of samplers, the presence of cuttings in sampling tubes, or the effects of using bent, corroded, or nonstandard tubes for sampling.

5.2.3 Naturally occurring fissures, shear planes, etc.

5.2.4 The presence of intrusions within the sample, such as calcareous nodules, gravel, or shells.

5.2.5 Sand and silt seams, organic matter, large voids, and channels developed by natural or artificial leaching of soil components.

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/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice **D3740** does not in itself ensure reliable testing. Reliable testing depends on many factors; Practice **D3740** provides a means of evaluating some of those factors.

6. Apparatus

6.1 *X-Ray Radiography Equipment*—Equipment with a peak current of approximately 15 mA is needed for a wide range of applications capable of accommodating commercially available film or detector plates, suitable for the sample sizes to be X-rayed, and suitable for the sample holders. The equipment may be equipped with a fluoroscope.

6.1.1 Use of equipment that produces digital images is permitted. Typical digital image pixel resolutions range from 30 to 350 μm [0.001 to 0.014 in.]. Image resolution shall be minimized and adjusted based on the diameter of the soil core to maximize the clarity of the image.

6.2 Although equipment with a voltage output of 100 kV is often used, certain types of samples may require equipment capable of performing at lower voltages (for example, 40 kV). For maximum resolution in certain types of applications a fine focus X-ray tube may be necessary. Persons inexperienced with X-ray radiography should discuss their specific equipment needs and the requirements of these methods with equipment manufacturers prior to purchasing.

NOTE 2—Equipment with beryllium window X-ray tubes may be necessary to perform radiography at low voltages.

6.3 *Soil Slice Trough*—A trough that is formed by cutting the sample tube/liner along its vertical axis through the soil sample. An example trough is shown in Fig. 1.

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.