Designation: D6027/D6027M – 24

Standard Practice for Calibration/Verification of Linear Displacement Transducers for Geotechnical Purposes[1]

This standard is issued under the fixed designation D6027/D6027M; 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 practice outlines the procedure for calibration/verification of displacement transducers and their readout systems for geotechnical purposes. It covers any transducer used to measure displacement, which gives an electrical output that is linearly proportional to displacement. This includes linear variable displacement transducers (LVDTs), linear displacement transducers (LDTs) and linear strain transducers (LSTs).

1.2 This calibration/verification procedure is used to determine the relationship between output of the transducer and its readout system and change in length. This relationship is used to convert readings from the transducer readout system into engineering units.

1.3 This calibration/verification procedure also is used to determine the accuracy of the transducer and its readout system over the range of its use to compare with the manufacturer's specifications for the instrument and the suitability of the instrument for a specific application.

1.4 *Units*—The values stated in either SI units or inch-pound units given in brackets are to be regarded separately as the standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combination values from the two systems may result in non-conformance with standard.

1.5 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026 unless superseded by this standard.

1.5.1 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 significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any consideration for the user's objectives; 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 analytical methods for engineering design.

1.6 This practice offers a set of instructions for performing one or more specific operations. This standard 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.

1.7 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *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

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.95 on Information Retrieval and Data Automation.

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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.

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

E2309/E2309M Practices for Verification of Displacement Measuring Systems and Devices Used in Material Testing Machines[3]

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions of common technical terms used in this practice refer to Terminology D653. For definitions of common metrology terms used in this standard, refer to the International Vocabulary of Metrology.[4]

3.1.2 *calibrated range, n*—distance over which the linear displacement sensor system is calibrated.

3.1.3 *calibration, n*—operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication.

3.1.4 *displacement measurement standard, n*—system consisting of micrometer or Precision Gauge Blocks combined with an appropriate device for indicating the magnitude (or a quantity proportional to the magnitude) of deformation of the member under an applied displacement

3.1.5 *displacement transducer, n*—an electrical transducer which converts linear displacement to electrical output.

3.1.6 *metrological traceability, n*—property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.

3.1.7 *power supply, n*—a voltage source with output equal to that required by the sensor.

3.1.8 *readout system, n*—electronic equipment that accepts output from the signal conditioner for the transducer and provides a visual display or digital record of the transducer output.

3.1.9 *signal conditioner, n*—electronic equipment that makes the output of the transducer compatible with the readout system. The signal conditioner may also filter the transducer output to remove noise.

3.1.10 *total linear range (TLR), n*—total distance that the core may move from the position of maximum voltage output to the position of minimum voltage output with a linear relationship between displacement and voltage.

3.1.11 *transducer, n*—device, used in measurement, that provides an output quantity having a specified relation to the input quantity.

3.1.12 *verification, n*—provision of objective evidence that a given item fulfils specified requirements.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *core, n*—central rod that moves in and out of the transducer body.

3.2.2 *null position, n*—the core position within the sensor body at which the transducer voltage output is zero (some transducers may not have a null position).

3.2.3 *percent error of displacement, E_r, n*—the ratio of the displacement measurement error to the applied displacement as measured by the displacement measurement standard, expressed as a percent.

4. Summary of Practice

4.1 A displacement transducer is mounted in such manner to permit it to be subjected to a precise, known displacement.

4.2 Displacement is applied in steps over the full range of the transducer and readings taken from the readout device.

4.3 The slope of the best-fit straight line relating sensor readout data to displacement is determined by linear regression.

4.4 The percent error of the transducer readout system is calculated and compared with the requirements for the specific use of the sensor.

4.5 See Appendix X1 for a flowchart of the calibration/verification process.

4.6 See Appendix X2 for identifying and determination measurement uncertainty component during a displacement transducer system calibration/verification.

5. Significance and Use

5.1 The displacement transducer plays an important role in geotechnical applications to measure change in dimensions of specimens.

5.2 The displacement transducer must be calibrated/verified for use in the laboratory to ensure reliable conversions of the sensor's electrical output to engineering units.

5.3 The displacement transducer should be calibrated/verified before initial use, at least annually thereafter, after any change in the electronic configuration that employs the sensor, after any significant change in test conditions using the transducer that differ from conditions during the last calibration/verification, and after any physical action on the transducer that might affect its response.

5.4 Displacement transducer generally has a working range within which voltage output is linearly proportional to displacement of the transducer. This procedure is applicable to the linear range of the transducer. Recommended practice is to use the displacement transducer only within its linear working range.

NOTE 1—Verification as in Practices E2309/E2309M should not be confused with calibration

6. Apparatus

6.1 *Linear Displacement Transducer,* to be calibrated.

6.2 *Power Supply with Output,* equal to that required by the sensor.

[3] These practices are under the jurisdiction of ASTM Committee E28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.01 on Calibration of Mechanical Testing Machines and Apparatus.

[4] *International vocabulary of metrology—Basic and general concepts and associated terms (VIM)*, 3rd Edition. Joint Committee for Guides in Metrology, 2012. https://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2012.pdf