Designation: D 6027 – 96$^{\epsilon 1}$

Standard Practice for Calibrating Linear Displacement Transducers for Geotechnical Purposes[1]

This standard is issued under the fixed designation D 6027; 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—This standard was corrected editorially in January 2000.

1. Scope

1.1 This practice outlines the procedure for calibrating linear displacement transducers (LDTs) 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 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 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 *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:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

3. Terminology

3.1 *Definitions*—Definitions of terms used in this practice are in accordance with Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibrated range*, *n*—distance for which the transducer is calibrated.

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

3.2.3 *linear displacement transducer (LDT) or linear variable displacement transducer (LVDT)*, *n*—an electrical transducer which converts linear displacement to electrical output. A LVDT consists of a LVDT body and a LVDT core which can be removed. A LDT holds the core within the sensor body.

3.2.4 *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).

3.2.5 *percent error*, *n*—the difference between a measurement of a reference standard and the actual length of the reference standard divided by the reference standard and the result converted to percent.

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

3.2.6.1 *Discussion*—Some LVDTs use ac voltage while others use dc. The LVDTs and LDTs may be damaged if connected to the incorrect power supply.

3.2.7 *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.

3.2.8 *repeatability voltage error*, *n*—the difference in voltage output for successive measurements of the same reference standard.

3.2.9 *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.

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

3.2.11 *traceability certificate*, *n*—a certificate of inspection certifying that the transducer meets indicated specifications for its particular grade or model and whose accuracy is traceable to

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.95 on Information Retrieval and Data Automation.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

the National Institute of Standards and Technology or to another international standard.

4. Summary of Practice

4.1 A displacement transducer is mounted in a 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.

5. Significance and Use

5.1 The LDTs play an important role in geotechnical applications to measure change in dimensions of specimens.

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

5.3 The LDTs should be calibrated 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, and after any physical action on the transducer that might affect its response.

5.4 LDTs generally have 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 LDT only within its linear working range.

6. Apparatus

6.1 *Linear Displacement Transducer*, to be calibrated.

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

NOTE 1—Some LVDTs use ac voltage while others use dc. The LVDTs and LDTs may be damaged if connected to the incorrect power supply.

6.3 *Signal Conditioning, Readout Equipment, and Related Cables and Fittings*.

6.4 *Test Method A—Precision Gage Block Calibration*:

6.4.1 *Precision Gage Blocks*, a set of precision reference blocks traceable to the National Institute for Standards and Technology. A gage block set should contain sizes necessary to perform satisfactorily the calibration procedures as outlined in Section 9 over the total linear range of the transducer.

6.4.2 *Comparator Stand*, consisting of a base of warp-free stability and ground to a guaranteed flatness, a support column, and an adjustable arm onto which the sensor mounting block can be securely attached. Alternatively, mount the sensor in the configuration it will be used in such a way that gage blocks can be inserted to displace the core for calibration purposes.

6.4.3 *Sensor Mounting Block*, a device used to attach the sensor to the comparator stand. Alternatively, mount the sensor to the test equipment in which the transducer is to be used.

6.5 *Test Method B—Micrometer Fixture Calibration*:

6.5.1 *Micrometer Fixture*, a precision instrument for linear measurement capable of obtaining readings over the total linear range of the LDT. The spindle must be nonrotating and spring loaded. The micrometer fixture is to be calibrated annually by the manufacturer or other qualified personnel.

7. Hazards

7.1 **Safety Hazards:**

7.1.1 This practice involves electrical equipment. Verify that all electrical wiring is connected properly and that the power supply and signal conditioner are grounded properly to prevent electrical shock to the operator. Take necessary precautions to avoid exposure to power signals.

7.2 **Safety Precautions:**

7.2.1 Examine the sensor body for burrs or sharp edges, or both. Remove any protrusions that might cause harm.

7.2.2 The transducer can be permanently damaged if incorrectly connected to the power supply or if connected to a power supply with the wrong excitation level.

7.2.3 Follow the manufacturer's recommendations with regard to safety.

7.3 **Technical Precautions:**

7.3.1 The core and body of the LDT are a matched set. For best performance, do not interchange cores with other LDT bodies.

7.3.2 Replace the core and body if either shows any signs of dents, bending, or other defects that may affect performance of the device.

7.3.3 Store the body and core in a protective case when not in use.

7.3.4 Do not exceed the allowable input voltage of the sensor as specified by the manufacturer.

7.3.5 Do not connect a voltage source to the output leads of the sensor.

7.3.6 Do not over tighten the sensor within the mounting block.

7.3.7 The behavior of some transducers may be affected by metallic holders. If possible, the working holder should be used during calibration.

8. Calibration and Standardization

8.1 If using Test Method A, verify that the gage blocks are of sufficient precision and bias and in a clean, unscratched condition.

8.2 If using Test Method B, verify that the micrometer fixture is in good working order and of sufficient precision and bias.

9. Procedure

9.1 Perform this calibration in an environment as close to that in which the sensor will be used as possible. The LDT, calibration gage blocks, micrometer fixture, and comparator stand should be in the environment in which they are to be calibrated for at least 1 h prior to calibration to stabilize temperature effects.

9.2 Verify that the power supply is adjusted to supply the recommended voltage to the sensor.

9.3 With equipment turned off, connect all power supply, signal conditioning, and recording equipment exactly as it will