CALIBRATION OF LINEAR POTENTIOMETERS

1 PROCEDURE OVERVIEW

The calibration of a linear potentiometer is outlined in this procedure. A scaling factor is determined based on the use of a calibration jig and gauge blocks meeting the requirements of ASTM D6027 and E2309. The calibration process uses two calibration cycles to establish the scaling factor.

1.1 Student Responsibilities for Calibration

- Read and understand the requirements of this procedure
- Determine the upper and lower limits of calibration needed
- Set up data acquisition for calibration (See Section 4.3 for details)
- Gather calibration jig and gauge blocks
- Provide completed calibration record to FSEL staff

1.2 Staff Responsibilities for Calibration

- Read and understand the requirements of this procedure
- Verify the gauge blocks have a valid calibration
- Provide access to calibration jig and gage blocks
- Provide assistance or supervision as needed
- Archive completed calibration record

2 EQUIPMENT AND TOOLS

- Linear Potentiometer(s)
- Data Acquisition System
- Disposable Rubber Gloves
- Displacement Transducer Calibration Jig
- Set of Gauge Blocks (See Article 4.2)

3 PERSONAL PROTECTIVE EQUIPMENT

- Safety Glasses
- Safety Shoes
- Hardhat
- Disposable Rubber Gloves

4 DETAILED PROCEDURE

4.1 Select the set of verification displacements for calibration of the transducer.

4.1.1. Determine the upper and lower limits of the range of displacements, as well as the mode(s), over which the transducer will be verified.

The fully extension point on the instrument is not a recommended data point for calibration, as most linear potentiometers have a bit of play at the beginning of the stroke. It is therefore recommended to choose a calibration point less than 0.05 in. from the end of the stroke. Near the fully retracted point, care should be taken to avoid excess compressing on the plunger as this can cause permanent damage to the instrument.

If the instrument is expected to lengthen during the test, the calibration should also be performed with the instrument lengthening with each step. If the instrument is expected to compress during testing, the calibration should also compress the instrument.

4.1.2. Select a set of five (5) or more verification displacements that are well distributed over the desired range of displacements and inclusive of the upper and lower limits identified above.

The distribution of the verification displacements over the desired range will be controlled by individual gauge blocks and combinations of gauge blocks. Verification displacements should be formed by the least number of gauge blocks possible and approximately equally distributed over the range of the instrument.

4.1.3. Record the selected set of verification displacements as well as the serial number, or other unique identifier, of the linear potentiometer.

An electronic form for recording pertinent information and data is attached to this procedure (Att. 5.1). The completed form will serve as the official record of the transducer calibration.

4.2. Choose an appropriate set of gauge blocks for calibration.

FSEL maintains two sets of gauge blocks: a calibration set and a verification set. The calibration set of gage blocks is calibrated by an external laboratory on a recurring 5-year interval. This set is only to be in the electronic shop or other similarly controlled and clean environment. The verification set of blocks relies on the original manufacturer's calibration data and is not periodically recalibrated. This set can be used anywhere in the laboratory including on the main testing floor.

It is intended that initial linear potentiometer calibration be performed in a controlled environment using the calibration set of gauge blocks. If needed, linear potentiometer function can be recalibrated or checked with the verification set of gage blocks while it is in place within its test setup.

4.2.1. If using the calibration gauge blocks, verify that the ASME B89.1.2 or equivalent calibration of the gauge blocks was completed by an A2LA-, NVLAP-, ACLASS-, L-A-B-, IAS-, or PJLA-accredited laboratory in conformance with the requirements of ISO 17025 (Ref. 6.4).

Calibration gauge blocks must be recertified according to ASTM B89.1.2 (Ref. 6.1) or an equivalent standard at intervals not exceeding 5 years.

4.2.2. Record the serial number of the gauge block set on the calibration record and note it as the calibration or verification set of gauge blocks.

4.3. Allow the displacement transducer and indicator or data acquisition system to equalize in the calibration environment.

4.3.1. Place the transducer in a calibration jig or other similar device as necessary to obtain repeatable measurements

4.3.2. Connect the transducer to the indicator or data acquisition system and provide power to both devices.

4.3.3. Configure the data acquisition software to output and record the excitation voltage and output voltage for the instrument at each verification displacement chosen in Article 4.1.2.

4.3.4. Record the applicable hardware and software configurations of the transducer and indicator or data acquisition system (e.g. serial numbers of hardware, excitation voltages, etc.).

Each calibration is only valid for the configuration noted within the calibration record. Use of a calibration with a configuration other than that noted in the calibration record should be avoided.

4.3.5. Allow the transducer and indicator or data acquisition system to equalize in the calibration environment for a minimum of 10 minutes.

Equalization of the devices is necessary to ensure stable readings.

4.4. Prepare for appropriate handling and wringing of the gauge blocks.

4.4.1. Wash hands thoroughly.

4.4.2. Wear disposable rubber gloves when handling the gauge blocks.

4.4.3. Wipe excess oil from the contact surfaces as necessary to ensure that the gauge blocks may be wrung together.

4.5. Adjust the initial position of the transducer body as necessary to accommodate insertion of the full range of gauge blocks and to record a data point near the zero-point of the instrument.

To ensure calibration over the range of the instrument, the initial reading should be recorded very near the full extension of the potentiometer plunger the full compression of the potentiometer plunger. These endpoints can be found by observing voltage output while slowly manipulating the plunger near the ends of the stroke. The near-endpoint calibration data points should be taken within about 0.05 in. of the ends of the stroke as identified through the above observation and Article 4.1.1.

Each transducer will be used to monitor relative, as opposed to absolute, changes in displacement. The initial position of the transducer armature may therefore be slightly offset from the absolute zero, and correspondingly, displacement verification may be completed based on relative changes in plunger position.

4.6. Complete a minimum of two calibration runs by progressively displacing the transducer armature with individual gauge blocks and wrung combinations of gauge blocks.

Do not tare the system prior to running the calibrations.

4.6.1. Obtain an initial reading for the displacement transducer.

The initial reading may be completed with or without a gauge block in between the armature and fixed reference surface but should be taken near the end of the potentiometer stroke per Article 4.5.

4.6.2. Use an individual gauge block, or wrung combination of gauge blocks, to displace the armature a known amount in the ascending direction.

4.6.3. Record the voltage indicated by the transducer, the excitation voltage applied to the instrument, and the actual displacement (relative to the initial position) imposed by the gauge blocks.

4.6.4. Continue to use individual gauge blocks, and wrung combinations of gauge blocks, to displace the armature and complete readings for the mode(s) and range of displacements identified in Article 4.1.2.

4.6.5. Repeat the calibration runs as desired, but not less than two runs per calibration.

4.7. Calculate the sensitivity for the potentiometer

Calculations should be performed based on a least-squares regression. This method is used in the Excel template for determining linear potentiometer effective length values. Input cells are highlighted in the Excel file. Values should only be input into these highlighted cells.

4.7.1 Identify the nominal length of the displacement transducer and input this value into the calibration spreadsheet.

Generally, a linear potentiometer is calibrated over its entire stroke. However, they can be calibrated over a smaller range if needed for a particular application. If a smaller range is used, this range should be clearly marked on the linear potentiometer and used as the basis for calculating calibration factors.

4.7.2 Based on the data file produced from the data acquisition system, determine the average excitation voltage that was supplied to the instrument during the calibration, and enter this value into the calibration spreadsheet.

Excitation voltages will likely change slightly during calibration. If excitation voltage deviates from the average value by more than about 1 percent, the calibration should be repeated.

4.7.3 Enter the output voltage of the linear potentiometer as recorded by the data acquisition system and the thickness of the gauge block or wrung combinations of gauge blocks at each of the verification displacements into the calibration spreadsheet.

4.7.4. Once the data above are entered, the spreadsheet will calculate scaling factor and associated measurement error.

4.8. Confirm the errors calculated in 4.7 do not exceed 0.50 percent of the full stroke of the potentiometer.

For 2-in. linear potentiometer, 0.50 percent error based on the full stroke of the instrument represents an absolute error of 0.01 in. If error exceeds 0.50 percent limit, the calibration should be repeated. If repeated calibrations are unable to reduce the error to acceptable levels, the linear potentiometer may not be functioning properly and should be marked as such after informing pertinent project and FSEL personnel.

If an older effective length is available for the instrument (from either factory calibration or a previous calibration at FSEL), compare the result of the new calibration with the existing number. If the difference is greater than 5 percent, inform pertinent project and FSEL personnel before using the new calibration parameters.

4.9. Following successful calibration, affix a label to the linear potentiometer to indicate (a) the calibration date, (b) the effective length in in., and (c) range of calibration in in.

Calibration of the linear potentiometer should ideally be completed on a pre-use, annual, incidental, and post-use (i.e. completion of program) basis.

If a label will not fit on the instrument, this step can be omitted if all pertinent data are present in the calibration worksheet and that worksheet is provided to FSEL staff.

4.10 Enter the necessary information into the “Calibration Results” sheet of the calibration template.

Input cells are highlighted in the Excel file. Values should only be input into these highlighted cells.

4.11 Provide electronic copies of all calibration records generated during implementation of this procedure to the pertinent project or FSEL personnel for their signature.

Once this template is completed, send to FSEL staff to be archived.

4.12 Save an electronic version of these results in PDF form and store on the FSEL file server.

The calibration records should also be linked to the inventory record of the linear potentiometer being calibrated.

5 SUPPORTING DOCUMENTS

5.1. Ferguson Structural Engineering Laboratory. *FSEL Linear Potentiometer Calibration Template*.

6 REFERENCED DOCUMENTS

It is the responsibility of project personnel to ensure that the most recent versions of the referenced FSEL documents are used during procedure implementation.

6.1. ASME B89.1.2: *Calibration of Gage Blocks by Contact Comparison Methods*. New York: American Society of Mechanical Engineers, 1991.

6.2. ASTM D6027-15: *Calibrating Linear Displacement Transducers for Geotechnical Purposes.* West Conshohocken: ASTM International, 2015.

6.3. ASTM E2309-16: *Verification of Displacement Measuring Systems and Devices Used in Material Testing Machines.* West Conshohocken: ASTM International, 2016.

6.4. ISO/IEC 17025-05: *General requirements for the competence of testing and calibration laboratories.* Geneva: International Organization for Standardization and International Electrotechnical Commission, 2005.

RECORD OF REVISIONS

Revision	Date	Affected Pages	Description
0	2016-06-17	All	Initial Issue