FSEL PROCEDURE FOR CALIBRATION OF PRESSURE TRANSDUCERS

1 PROCEDURE OVERVIEW

The calibration of a pressure transducer is outlined in this procedure. A sensitivity is determined based on the use of a dead-weight pressure tester. The calibration process applies pressure using two cycles.

The dead weight pressure tester is a durable calibration standard. Note that the weights are not calibrated on a regular basis and as such, the calibration of the pressure transducer is not traceable to a NIST standard.

1.1 Student Responsibilities for Calibration

- Read and understand the requirements of this procedure
- Determine the upper and lower limits of calibration needed
- Move pressure transducer to be calibrated to dead weight pressure tester
- Move data acquisition to be used for calibration to dead weight pressure tester
- Set up data acquisition for calibration (See Section 4.3 for details)

1.2 Staff Responsibilities for Calibration

- Read and understand the requirements of this procedure
- Instruct student in use of dead weight pressure tester
- Sign and retain digital copies of calibration records

2 EQUIPMENT AND TOOLS

▪ Pressure Transducer ▪ Data Acquisition System ▪ Dead Weight Pressure Tester and Weights

3 PERSONAL PROTECTIVE EQUIPMENT

▪ Safety Glasses ▪ Safety Shoes ▪ Hardhat

4 DETAILED PROCEDURE

4.1 Select the corresponding set of verification pressures for calibration of the pressure transducer.

4.1.1 Determine the upper limit of the range of pressures over which the transducer will be verified.

The dead weight pressure tester can generate pressures from 100 to 10,000 psi in increments of 50 psi. The pressure is produced by calibrated weights acting on a precisely machined piston. The initial reading for calibration of pressure transducers should be taken at 100 psi.

4.1.2 Select a set of verification pressures that are well distributed over the desired range of pressures and inclusive of the upper and lower limits identified above.

Typically, 5 to 10 verification pressures are used for calibration. For example, typical verification pressures for a 10,000 psi pressure transducer are: 100, 1,000, 2,000, 3,000, 4,000, 5,000, 6,000, 7,000, 8,000, 9,000, and 10,000 psi.

4.1.3 Record the selected set of verification pressures and the serial number, or other unique identifiers, of the pressure transducer.

An electronic Excel form for recording pertinent information and data is available and recommended for use with this procedure. The completed form will serve as the official record of the load cell calibration.

4.2 Verify that the dead weight pressure tester to be used for load cell calibration is in working order.

The dead weight pressure tester relies on dead weight and a precisely machined piston to generate pressure. Provided these parts are in good working order, no calibration of the pressure tester is necessary. However, before use, the tester should be inspected for damage and leaks. The primary pressure wheel should be fully extended and retracted to verify function. Any questions should be directed to FSEL technical staff.

4.3 Allow the pressure transducer and data acquisition system to equalize near the testing machine.

4.3.1 Connect the pressure transducer to the hydraulic fitting in the dead weight tester.

Ensure that the dead weight tester is not pressurized before attaching the transducer. If the tester is pressurized, it will be difficult to attach the transducer. The pressure can be removed by turning the primary wheel on the tester.

4.3.2 Connect the pressure transducer to the data acquisition.

4.3.3 Configure the data acquisition software to output and record the excitation voltage and output voltage for the pressure transducer at each load step.

The calibration calculation template uses these two quantities (excitation and output voltages) to determine the appropriate scaling factor.

4.3.4 Record the applicable hardware and software configurations of the pressure transducer and data acquisition system (i.e. serial numbers of hardware, scaling factor, excitation voltages, etc.).

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

Equalization of the devices within the vicinity of the testing machine is necessary to ensure stable readings.

4.4 Implement and repeat the operations outlined in Articles 4.5 through 4.7 as necessary to calibrate the pressure transducer over the full set of verification pressures.

4.5 Prior to pressure application, zero the indicator or data acquisition system of the pressure transducer being calibrated at zero pressure in the dead weight tester.

Due to the mechanism of the dead weight pressure transducer, it is not capable of generating an absolute zero pressure. To obtain a practical zero point, remove all weights from the pressure tester, and back-out the primary wheel until the piston at the top of the tester is resting on the housing.

4.6 Apply pressure to the dead weight tester

4.6.1. Add the increment of dead weights to the tester piston.

Note that the piston itself generates 100 psi of pressure and add weights accordingly.

4.6.2. Pressurize the tester using primary wheel.

The primary wheel should be turned until the dead weight piston rises within its housing. The dead weight piston should float on the hydraulic fluid and be free of its upper and lower stop points. Confirm that the dead weight is free by gently spinning the weights while being careful to avoid toppling the dead weights or inducing any bouncing into the weights.

4.6.3. Record excitation and output voltage from the pressure transducer and record the total pressure applied by the dead weights in psi.

4.6.4. Repeat Articles 4.6.1 through 4.6.4 as necessary to apply all pressure increments identified in Article 4.1.2 in at least two calibration cycles.

4.6.5. Once a calibration run is completed up to its maximum pressure, the primary wheel should be used to completely relieve the pressure on the system.

If pressure is not relieved, the piston can impact the housing as the dead weights are removed.

4.7. Export or record the excitation and output voltages for the pressure transducer being calibrated at each verification pressure from the data acquisition system and record the verification pressure based on the dead weights.

4.8. Calculate the sensitivity.

Calculations should be performed based on a least-squares regression. This method is used in the Excel template for determining load cell sensitivity values.

4.8.1 Identify the nominal pressure transducer capacity and input this value into the calibration spreadsheet.

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

Generally, a pressure transducer is calibrated over its entire range. However, pressure transducers 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 pressure transducer and used as the basis for calculating calibration factors.

4.8.2 Based on the data file produced from the data acquisition system, determine the average excitation voltage that was supplied to the pressure transducer 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 1 percent, the calibration should be repeated.

4.8.3 Enter the output voltage of the pressure transducer as recorded by the data acquisition system and the applied pressure based on the sum of the dead weights at each of the verification pressures into the calibration spreadsheet.

If a National Instruments or Campbell Scientific data acquisition system is used for calibration, the voltage recorded and output by the control software may be normalized by the instantaneous excitation voltage. Thus, each individual output voltage may need to be multiplied by the excitation voltage prior to use in the Excel template. Consult with FSEL staff should there be any question about the normalization of voltages.

If a Keysight/Agilent system was used for calibration, the output voltage need not be multiplied by the excitation voltage if Article 4.3.3 was followed during calibration.

The template uses Excel's least squares regression function to calculate sensitivity as the slope of the best-fit line, in mV/V. The sensitivity is calculated for the three different data acquisition systems used at FSEL: Keysight/Agilent, Campbell Scientific, and National Instruments.

4.9 Confirm the errors calculated in pressures do not exceed 1 percent of the full-scale capacity of the pressure transducer.

If error exceeds 1 percent of the full-scale capacity, the calibration should be repeated. If repeated calibrations are unable to reduce the error to acceptable levels, the pressure transducer may not be functioning properly and should be marked as such after informing pertinent project and FSEL personnel.

If an older sensitivity parameter is available for the pressure transducer (from either a 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 10 percent, inform pertinent project and FSEL personnel before using the new calibration parameters.

4.10 Following successful calibration, affix a label to the pressure transducer to indicate (a) the calibration date, (b) the sensitivity in mV/V, and (c) range of calibration in psi.

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

4.11 Enter the necessary information into the "Calibration Results" sheet of the calibration template.

Input cells are highlighted in the Excel file. Value should only be input into these highlighted cells. Once this template is completed, send to FSEL staff to be signed and archived.

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

4.13 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 pressure transducer being calibrated.

5 SUPPORTING DOCUMENTS

5.1. Ferguson Structural Engineering Laboratory. *FSEL Pressure Transducer Calibration Template*.

6 REFERENCED DOCUMENTS

None.

RECORD OF REVISIONS

Revision	Date	Affected Pages	Description
0	2016-MM-DD	All	Initial Issue