Load cell calibration report

Illustrating common tasks in reproducible reporting

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# Introduction

Calibrating a *load cell* (a sensor for measuring uniaxial force) yields two main results: a calibration equation relating output voltage (mV) to input force (lb); and an estimate of sensor accuracy as a percentage of full span. In this report, I present the test results for an Omega LCL-005 load cell calibrated following the ANSI/ISA procedure [1].

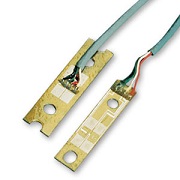


Figure 1. Omega LCL005 load cell (replace stock photo with image of our setup)

The data, shown in Table 1, has 41 observations over 6 up-down cycles. Per the ANSI/ISA standard, the test begins and ends at a midspan test point in the same direction, thus the first and last cycle are incomplete (indicated by NA).

Table 1: Calibration data

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Test point | Force (lb) | Cycle 1 (mV) | Cycle 2 (mV) | Cycle 3 (mV) | Cycle 4 (mV) | Cycle 5 (mV) | Cycle 6 (mV) |
| 2 up | 1.5 | NA | 29.9 | 30.2 | 29.5 | 30.7 | 30.7 |
| 3 up | 2.5 | 51.1 | 49.4 | 49.7 | 49.6 | 48.5 | 51.6 |
| 4 up | 3.5 | 70.4 | 70.0 | 70.1 | 70.7 | 71.0 | NA |
| 5 up | 4.5 | 88.8 | 91.6 | 89.5 | 91.4 | 91.2 | NA |
| 4 dn | 3.5 | 69.4 | 69.0 | 68.5 | 68.6 | 70.8 | NA |
| 3 dn | 2.5 | 49.5 | 50.1 | 49.8 | 49.2 | 50.6 | NA |
| 2 dn | 1.5 | 30.7 | 30.8 | 29.2 | 28.5 | 30.0 | NA |
| 1 dn | 0.5 | 8.7 | 10.9 | 10.6 | 10.7 | 9.5 | NA |

# Analysis

*Calibration curve.* The independent variable in this calibration is the sensor input (force) and the dependent variable is the sensor output (voltage readings). Performing a linear regression yields the results summarized in Table 2.

Table 2: Regression results

|  |  |  |
| --- | --- | --- |
| Result | Value | Units |
| slope | 20.04 | mV/lb |
| intercept | -0.09 | mV |
| adjusted | 1.00 | mV |
| max residual | 1.58 | mV |
| min residual | -1.56 | mV |

Thus the calibration equation in terms of the force (lb) and the sensor readout (mV) is given by

and the calibration curve is shown in Figure 2. The data markers in the graph have been jittered to reduce overprinting, but the regression line is based on non-jittered values.

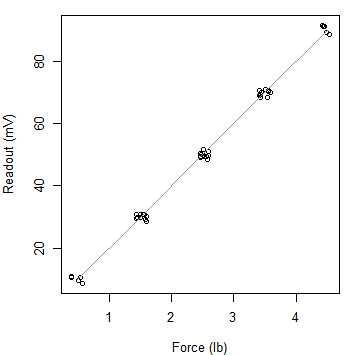


Figure 2: Calibration curve.

*Accuracy.* Accuracy is defined as the largest positive and the largest negative residuals of the regression. Thus, from Table 2, the accuracy bounds are mV and mV. The residuals are plotted in Figure 3 with the upper and lower bounds indicated with dashed lines.

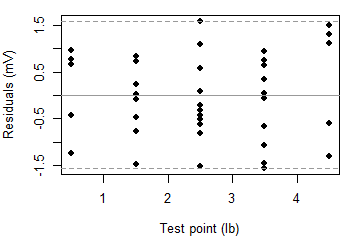


Figure 3: Residuals from the linear regression

As a percentage of span, sensor accuracy is and %. Many users prefer a single value to estimate systematic uncertainty in a measurement, so we take the more conservative of the two numbers and report

accuracy of reading

# References

1. (1993) *Process instrumentation terminology*, American National Standards Institute/International Society of Automation, ANSI/ISA-S51.1-1979 (rev. 1993).