Calibration of Two Pressure Measurement Systems Using a Deadweight Tester, 2019 Fall

Objective

You will calibrate two independent pressure measurement systems: an analog gauge and an electronic pressure transducer with an A/D computer interface. The purpose of calibrating the systems is to relate the sensor output to the quantity we are attempting to measure, to minimize any bias error and to quantify the random error associated with using each system.

Test Procedure

You will calibrate the two systems simultaneously using the deadweight tester. We will regard the pressures produced by the tester as shown by the values stamped on the weights as the exact true pressures. Each group will record the true pressure, the pressure indicated on the analog gauge, and the voltage output by the pressure transducer. EACH GROUP WILL ANALYZE ONLY ITS DATA SET. TO FACILITATE THIS, INSTRUCTORS, PLEASE GIVE EACH GROUP ONLY ITS DATA.

Data Requirements

You will produce a data table consisting of three columns:

1. The true applied pressures from 5 *psig* to 105 *psig*.
2. The analog pressures read from the gauge.
3. The voltages read from the transducer. Read four digits to the right of the decimal point.

Calculated Results

For <u>each</u> of the <u>two</u> measurement systems:

1. Plot the data (as symbols) as described on slide 5 of the presentation.
2. Find the linear curve fit coefficients as described on slide 9 of the presentation. Use equations (4a) and (4b) to find these coefficients and determine the units of the coefficients, c_1 and c_2.

   If you wish, you may also compare your calculated curvefit coefficients to those found by software like EXCEL (trendline) or MATLAB (polyfit). However, please rely on your own calculations for these coefficients.
3. Now on the same plot on which you have plotted the data, plot the line representing the curve fit. It should appear as a best fit, if you've done everything correctly.
4. Now rearrange your curve fit equation to find the so-called **field equation**, which would allow us to determine true pressure measurements based on indicated measurements were we to use our measurment system in the field. In other words, obtain an equation similar to equation 5 on slide 10.

5. Find the standard error, S, as described by equation 8 on slide 12 and propagate the error to obtain a final **field equation** that includes an error estimate such as equation 10 on slide 13 (but see comment below).

   Comment: Our calibration process can, and should, minimize bias errors that would result in using, say, the analog gauge without calibration. However, the calibration process cannot reduce the random error associated with reading the gauge. Since we have estimated this random error as $\pm\frac{1}{2}$ *least count* $= 1$ *psi*, we should really replace S with 1 *psi* in equation 10, if 1 *psi* is larger than S. If you find this to be the case, revise your last answer.

   Let the confidence level be 95 *percent*–you will need to find the appropriate z from a tabulation of the standard normal distribution.

Also answer the following two questions:

6. Assume that you are now using your calibrated analog pressure gauge to make a reading in the field. You read a value of 64 *psi* on the gauge. Use your field equation to report the true pressure at 95 percent confidence. Be sure to report your result with a value with an appropriate number of digits, an uncertainty bracket, units, and a confidence level.

7. Assume that you are now using your calibrated pressure transducer to make a reading in the field. You read a value of 1.4320 V. Use your field equation to report the true pressure at 95 percent confidence. Be sure to report your result with a value with an appropriate number of digits, an uncertainty bracket, units, and a confidence level.