MAE 3340 *INSTRUMENTATION SYSTEMS*

Laboratory Exercise 6: Using Strain Measurements to Measure the Pressure Inside of a Full Soda Can

STUDENT NAME: ____

SECTION/Team Name: ____

Lab Objective: Perform Pressure Vessel Stress Measurements

Introduction:

This week, we are going to use a backdoor method to determine the pressure inside of a full soda can. When we open the can, the pressure will fall to atmospheric, and the can will shrink. You can use the above formulas to relate the change in strain to the change in pressure. We can measure ε, t, and D to get Δp. Follow the analysis procedure outlined in the Lab 6 lecture notes. ***You may turn in this completed document as the laboratory report.***

Executive Summary: *Describe what you did, and what you learned in this lab.*

Required Equipment:

- *Vishay P-3500 Strain Gauge Bridge Completion Box*
- *2-Strain gauges, copper termination wire, solder pads*
- *Red, black, and white 30 AWG strain gauge connection wires*
- *Soldering iron, solder, and flux*
- *Windex® Spray for degreasing*
- *Scotch® tape for installing strain gauges.*
- *Superglue, cotton balls/swabs, paper towels, and fine grit sand paper*
- *MyDAQ and snap in terminal connector*
- *BNC Connector cable and banana jack adapter*
- *Red and White Banana jack cables with alligator clips*
- *Jumper wires*
- *Full Soda Cans*

Installation Procedure: Carefully follow the procedures as laid out in the Lab 6 Lecture Notes:

• Break into 3 groups. Each Group will select two full soda cans. Measure their diameters at mid length using Laboratory calipers … *write down data … see table at end of this lecture*. Each group needs to apply a strain gage to the sides of each of the two cans.

• Get a copy of the Manual: "Student Manual for Strain Gage Technology" from the web page for section 5. There are several hardcopies in the lab. The instructions for application begin on page 17. Start reading at section 2. The procedure begins at section 3.

• Unfortunately, we cannot afford the expensive M-bond installation kits at $250 a pop -- so we are "making do" with cheap superglue (*"generic"* methyl-cyanoacrylate substitute), windex paper towels, cotton balls/swabs and sandpaper.

• Clean the can Windex® and paper towel. Use sand paper to clean can surface at installation point so that only bare metal shows ... then buff this area with a paper towel. Put a tiny drop of superglue on gauge and install with strain axis perpendicular to longitudinal axis of can. "Eyeball" is good enough ... do not bother with layout lines.

• Whenever you see reference to clean gauze, use the cotton balls that are provided. Be sure to dispose of the used ones. For our purposes, the application methods are the same except that the methyl–cyanoacrylate does not use the catalyst. Work fast as the glue sets in about 3 seconds. If your gage fails to stick, try again … use another can of soda if necessary. Do not use too much glue! Just a drop!

• You will be using two types of strain gauges for this lab. All Gauges are pre-wired with 36" 3-wire leads .. see Lab 6 notes for connection instructions

1) Gauges with 120 Ω nominal resistance

2) Gauges with 350 Ω nominal resistance

• Use the three-wire strain gauge wire setup to connect the terminal pads to the bridge circuit. This cable consists of a single group of wires with one red, black and white. You may need to solder extension wires to the 36" leads ... use the 3-wire 22 AWG strain gauge wire provided.

• When you think you have done it!, and yiur gauges are installed -- follow the setup procedures for the yellow Vishay P-3500 boxes as laid out in the Lab 6 lecture notes.

• *The Vishay box provides 2 volts of excitation voltage, and reads out in microstrain if the appropriate gage factor is dialed in. Turn the box on (press Amp Zero) and let it warm a few minutes before making any measurements. (These are battery-powered, so don't forget to turn it off when you are finished). If you lift the lid, you will see a diagram of how to connect your gage as a 1/4 bridge. You need to use the 120 dummy resistor by connecting to the yellow post labeled D120. Your gage and this dummy resistor form the bottom end of the bridge. When it is warm, zero the output using the Amp Zero wheel. Then press Gage Factor and dial in the correct value (on the box containing the gages). Then press run. Make sure that the 1/4-1/2 button is black and not yellow.*

• If you have wired the gauge correctly and it is working, a number will appear in the display. Make it zero using the balance switch and knob. This is balancing the bridge to output zero when the strain is zero. If you push in on the can, you should see the value change. The readout is in microstrain. Consider that you will zero the bridge before you start and that the can will get smaller when opened, which is to say negative or compressive strain.

• At this point you will modify your Voltmeter Virtual Instrument (from lab 2) to read the voltage display from the "Vishay box" ... *follow procedures laid out in Lab 6 lecture notes. Be sure to set the AO thumbwheel for maximum gain (440 μV/με)*

Test Procedure: Carefully follow the procedures laid out in the Lab 6 lecture notes.

• Each group will instrument two cans, one for each of the two strain gauge types each group will take turns opening the can and taking a measurement.

• Each group will open *Can 1* first. Then *Can 2* next.

• You will modify your VI from lab 2 to read MYDAQ channel zero, and also add an additional display for the strain measurement. Use the procedure in the lab 6 notes to calculate the appropriate Microstrains-to-Volts scale factor.

• Be sure to stop your VI in time to save your data and take a screen shot of the result. These screen shots will be included in your lab report. Practice starting an stopping your VI to be sure you can react quickly enough.

• After the can is opened and the reading is recorded … Disconnect can from P-3500 … have volunteer consume soda. Carefully cut open can at midpoint … just above the installed strain gauge … using scissors, Measure can wall thickness.

• Log data in table.

Data Analysis: As the data are acquired each group will populate the table shown below*.. **except the last two columns and the last two rows... these calculations are to be performed individually***. In total, there should be 6 successful entries. … one for each of the two cans for each of the three groups. In the Column labeled Volts, write down the voltage displayed by your VI when the can pressure reaches equilibrium. ***Use a student-generated spreadsheet to log the data.***

Group/Can#	**Gauge Nominal Resistance**	**Gauge factor**	**Can Diameter, cm**	**Wall t, cm.**	**ε, μStrain (Vishay digital display)**	**Volts Read**	**ε, μStrain (VI display)**	σ_{Hoop} ***kPa***	$P_{internal}$, ***kPa (gauge pressure)***
1	*120 Ohms*								
2	*350 Ohms*								
3	*120 Ohms*								
4	*350 Ohms*								
Sample Mean	-------------					-------------			
Sample Std. Dev.	-------------					-------------			

Individually, calculate the sample mean and standard deviation for each column including the Internal pressure in the can based on the populated measurement table. When this calculation is performed … fill in the following blanks ….below … show work and attach to Lab Report.

Part (1)

1) Sample Mean of the Pressure in the Can (kPa) ____

2) Sample Standard Deviation Pressure in the Can (kPa) __________________________________

3) Degrees of Freedom for the Measured Population______________________________________

4) Using the Student-T distribution for the required degrees of freedom, calculate the uncertainty range for the sample mean of the pressure in the can … use a 95% confidence interval. _________________ < sample mean < ____________________ (95%) confidence

Part (2):

• Select one student from each lab to email me the raw test results for each soda can

• I will distribute the results from all of the labs to the class for the post-lab analysis

Repeat the procedure from Part (1), except now use all of the collected data. Calculate the sample mean and standard deviation for Internal pressure in each can based all of the clected results (~ 60 data points) . …then fill in the following blanks below ….show work and attach to Lab REPORT

5) Sample Mean of the Pressure in the Can (kPa) ______________________________________

6) Sample Standard Deviation Pressure in the Can (kPa) _______________________________

7) Degrees of Freedom for the Measured Population___________________________________

8) Using the Gauss distribution for the required degrees of freedom, calculate the uncertainty range for the sample mean of the pressure in the can … use a 95% confidence interval. ________________ < sample mean < ___________________ (95%) confidence

Part (3):

9) Based on Manufacturer's specs for the various components of the measurement system ***(see lab lecture notes)*** … estimate uncertainty in Measured internal pressure in the soda can ________________________________

10) Compare estimated uncertainty with 95% confidence interval computed above ____

11) Attach VI screen shots at end of report.