

(EXPERIMENT NO. 4)

CALIBRATION OF A PRESSURE GAGE USING DEAD-WEIGHT TESTER

1. Theory

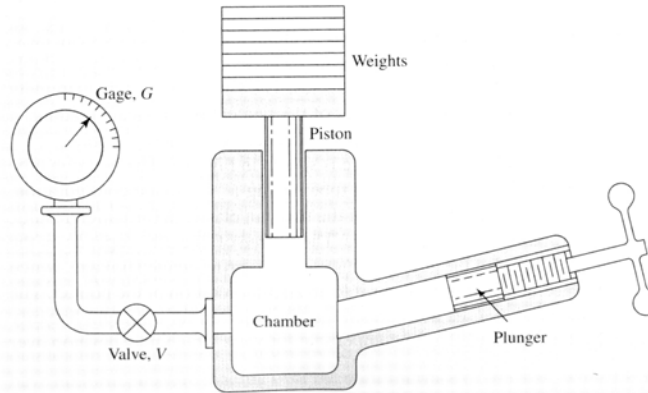


Figure 1. Deadweight Tester for Bourdon–tube pressure gage

A dead-weight tester is a device used for balancing a fluid pressure with a known weight. Typically, it is used for static calibration of pressure gages.

As seen in Figure 1, the apparatus is set up for calibration of the pressure gage G. The chamber and cylinder of the tester are filled with clean oil by first moving the plunger to its most forward position and then slowly withdrawing it while the oil is poured in through the opening for the piston. The gage to be tested is installed and piston pressure is now transmitted to the gage when the valve is opened. This pressure may be varied by adding weights to the piston or by using different piston-cylinder combinations of varying areas. The viscous friction between the piston and the cylinder in the axial direction may be substantially reduced by rotating the piston-weight assembly while the measurement is taken. As the pressure is increased, it may be necessary to advance the plunger to account for the compression of the oil and any entrapped gasses in the apertures.

The accuracies of dead-weight tester are limited due to: (1) the friction between the cylinder and the piston, (2) the uncertainty in the area of piston, (3) the buoyancy error and (4) gravity error.

The gravity error due to elevation, z [m], and latitude, ϕ [$^\circ$] can be corrected by the dimensionless correction factor as:

$$e_{gravity} = -(2.637 * 10^{-3} \cos(2\phi) + 2.9 * 10^{-8} z + 5 * 10^{-5}) \quad (1)$$



and the **air buoyancy error**, e_{buoyancy} , by

$$e_{\text{buoyancy}} = - \frac{\rho_{\text{air}}}{\rho_{\text{masses}}} \quad (2)$$

Then, the indicated pressure of gage, p_i , can be corrected as:

$$p = p_i (1 + e_{\text{gravity}} + e_{\text{buoyancy}}) \quad (3)$$

2. Experiment setup

Student will perform experiment using the Dead-weight tester (Figure 1). Students are allowed to use references, handbooks, standards and manufactures catalogs. Students should also demonstrate skills in using available software.

3. Step by step procedure

- 1) Mount the pressure gage to be calibrated in its place.
- 2) Remove the cylinder tap and read the pressure gage for zero value.
- 3) Place the piston into cylinder and read the pressure gage for the pressure which is written on the piston.
- 4) Add the first mass block on the cylinder and read the pressure gage. You need to advance the plunger as the weights are increased in order to insure free movement and rotation of the piston inside the cylinder
- 5) Repeat step 4 until all mass blocks are added (loading)
- 6) Tabulate the following data:
 - a. Experiment number,
 - b. The pressure gage readout, $p_{g,l}$,
 - c. The total pressure of the dead-weight tester (including the piston pressure), p_c ,
- 7) Remove the mass block which is lastly added and read the pressure gage (unloading)
- 8) Repeat step 7 until all mass blocks are removed
- 9) Tabulate the following data:
 - a. The pressure gage readout, $p_{g,u}$,
 - b. The total pressure of the dead-weight tester (including the piston pressure), p_c ,



Table (1) Experimental results

Exp #	Gage Pressure (loading), $p_{g,l}$, bar	Calibration Pressure, p_c , bar	Gage Pressure (unloading), $p_{g,u}$, bar	Gage Pressure p_{avg} (bar)	Corrected pressure p (bar)

4. Preparation of the report

The report of this experiment should be prepared according to the standard technical report writing format.

5. Data Analysis

1-For Jeddah location, take the latitude angle ϕ to be 21.67° , the elevation, z to be 12 m. Take the masses density (for Steel) to be 7900 kg/m^3 . Also measure the room temperature, and calculate the air density assuming ideal gas law and atmospheric pressure of 1 atm.

2- Calculate the gravity and buoyancy errors using Equations 1 & 2 above, and then use equation (3) to calculate the corrected pressure.

3-Use Excel program or similar graphing program to plot the variation of $p_{g,l}$ and $p_{g,u}$ with p (the corrected pressure

4-Calculate the maximum hysteresis error

5-Perform curve fit to find the calibration curve between p_{avg} and p

6-Find the uncertainty for the curve fit

7- Grading of the report will be according to grade distribution given in table (2).



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MEP 365: THERMAL ENGINEERING MEASUREMENTS



8-You may search the internet for more information about **deadweight testers** and similar experiments.

Table (2) Grading of the report

No	Item	Grade	Remarks
1	Attend lab session and participate effectively in performing the experiment	10	
2	Submit the report on time with tables filled correctly	10	
3	Plot the variation of $p_{g,l}$, $p_{g,u}$ with p	10	
4	Find the maximum hysteresis	10	
5	Plot the variation of p_{avg} with p	10	
6	Curve fit for p_{avg} with p and uncertainty calculations	10	
7	Prepare the report according to the technical report (i.e. cover sheet, table of contents, objective, introduction)	10	
8	Prepare the report according to the technical report format (i.e. Procedure, sketches, figures, discussions, conclusions, references)	10	
9	Use external sources for additional information (for example: library, internet, manual, etc)	10	
10	Overall impression about the report (organization, neatness, etc)	10	