Exercise A

Objective

- To calibrate a Bourdon type pressure gauge and to determine the gauge errors.
- To determine the measurement erros in the reference pressure source used for calibration.

Method

To calibrate a pressure gauge by applying predetermined pressures generated by loading weights on to a piston of known cross-sectional área (a "dead-weight calibrator").

Equipment Required

In order to complete the demonstration of the Bernoulli apparatus we need a number of pieces of equipment

- The F1-10 Hydarulics Bench
- The F1-11 Dead Weight Calibrator
- Weights (supplied with F1-11)
- Weigh-balance (not supplied)
- Pressure gauge (supplied with F1-11)
- Filling tuve or Measuring Cylinder (supplied with F1-10)

Theory

The use of the piston and weightss with cylinder generates a measurable reference pressure, p:

$$P = \frac{F}{A}\ (Pascals)$$

Where

F=Mg

And F is the forcé applied to the liquid in the calibrator cylinder.

M is the total mass (including that of the piston) and

A is the área of piston.

The área of the piston can be expressed in terms of its diameter, d, as:

$$A = \frac{\pi d^2}{4}$$

Equipment Set Up

Before setting up the equipment, determine the weight of the individual calibration masses and the weightt of the piston too, using a balance and note the measurement errors associated with this balance.

If a balance is not available to check the accuracythen the nominal values may be assumed (the piston has a nominal weight of 0.5kg).

Note that the piston is a high precisión component and must be treated with care. If more tan one F1-11 (or TH2) is used in the laboratory then care should be taken to avoid mixing pistons and cylinder. Correct pairing can be ensured by checking that the mark on the end of the piston matches the mark on the flange of the cylinder.

Position the dead-weight calibrator (without the piston) on the hydarulic bench top and ensure that the base is horizontal by adjusting the feet and using the spirit level. This is necessary to ensure vertical transfer of the applied load and free rotation of the piston.

Using the spirit level attached to the base, level the cylinder by adjusting the feet.

Attach the flexible tuve from the base of the cylinder to one of the tappings at the base of the Bourdon gauge.

Before operating the calibrator it will be necessary to prime the cylinder, the Bourdon gaugeand the interconnecting tubing to eliminate all air bubbles. This can be achieved by pouring water into the cylinder using the measuring cylinder or the filling tube supplied with F1-10. Alternatively water can be drawn into the system by raising the piston while one of the tappings is connected to a source of water using flexible tubing. Whichever technique is used to fill the system, it will be necessary to open and closet he cocks at the base of the Bourdon gauge and raise and lower the piston several times until the flexible tubing is full of wáter with no air bubbles and the cylinder remains full of wáter with the piston at the top of its travel.

Procedure

With the piston at the top of its travel inside the cylinder, spin the piston to reduce the stiction. The pressure exerted y the piston will be indicated onthe Bourdon gauge. Note the Reading on the gauge and the weight applied.

Place a 0.5kg weight on the piston then spin the piston and weight. Ensure that the piston rotates freely. The increased pressure due to the weight will be indicated onthe Bourdon gauge. Note the reading on the gauge and total weight applied.

Add calibration weights in steps of 0.5kg, spinning the piston and nothing the gauge reading and total weight applied after each increase in load.

If, due to the slight, but necessary, leakage (the piston musth be fit closely, but freely inthe cylinder), the piston reaches the cylinder bottom, more water must be admitted to the cylinder as describe in the equipment set up procedure.

Repeat the above process removing the weights pregressively.

Results

All readings should be tabulated as follows:

Mass of Piston Mp kg	Diameter of Piston d m	Area of Piston A m2	Mass of Weights Mw kg	Total Mass M kg	Gauge Reading G KN/m^2	Cylinder Pressure P KN/m^2	Absolute Gauge Error KN/m^2	% Gauge Error
		(πd^2)/4		Mp + Mw		Mg/A	G-P	((G-P)/P)*100

Plot a graph of gauge reading against absolute gauge error and of gauge reading against % gauge error.

Conclusions

- Comment on the accuracy of the gauge
- Comment on the size of gauge errors in relation to the errors in the reference pressure measurements.
- Is the relative height between the dead-weight calibrator and the gauge important in the calibration?

Nomenclature

Name	Unit	Symbol	Type	Definition
Mass of Piston	g	Mp	Measured	Given piston mass
Diameter of Piston	m	d	Measured	Given piston diameter
Area of Piston	m2	A	Calculated	A=(πd^2)/4
Mass of Weights	kg	Mw	Measured	Weights applied to the calibrator
Total Mass	kg	M	Calculated	M=Mp+Mw
Gauge Reading	kN/m2	G	Measured	The reading taken from the Bourdon Gauge
Cylinder Pressure	kN/m2	p	Calculated	p=Mg/A
Absolute Gauge Error	kN/m2	E_A	Calculated	EA=G-P
% Gauge Error	%	$E_{\%}$	Calculated	E%=((G-P)/P)*100

Technical Data

The following dimensions from the equipment are used in the appropiate calcultions. If required these values may be checked as part of the experimental procedure and replaced with your own measurements:

Mass of piston: M_p = 498g

Diameter of piston: d = 0.01767m