H30
Pressure Measurement Apparatus

TecQuipment has taken care to make the contents of this manual accurate and up to date. However, if you find any errors, please let us know so we can rectify the problem.

TecQuipment supplies a Packing Contents List (PCL) with the equipment. Carefully check the contents of the package(s) against the list. If any items are missing or damaged, contact TecQuipment or the local agent.

TecQuipment

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SECTION 1.0 Introduction

Figure 1 H30 Pressure Measurement Bench

1.1 H30 Apparatus

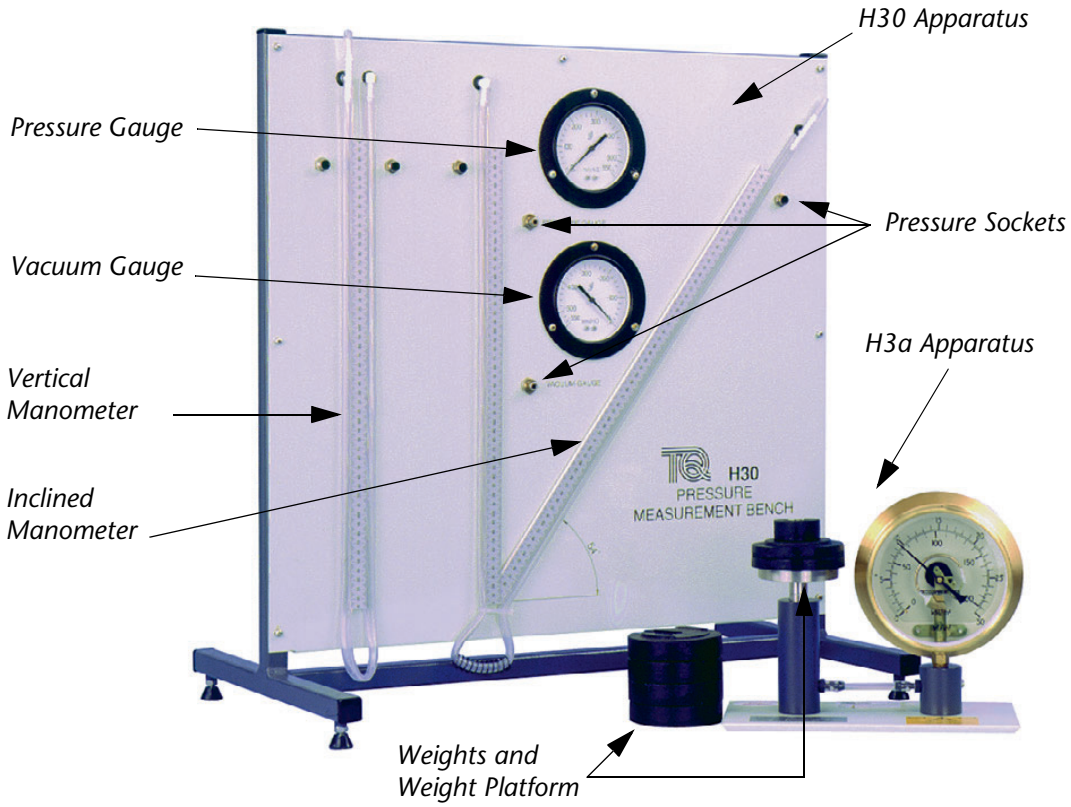
The TecQuipment H30 Pressure Measurement Bench is shown in Figure 1. It is used to compare ways of measuring pressure. Manometry is a fundamental method of measuring low pressure and, together with Bourdon type gauges, is widely used in engineering.

The apparatus consists of a steel framework/bench construction with vertical and inclined manometers, and two Bourdon type gauges. One of the gauges measures pressure, the other measures vacuum. The gauges and manometers each have pressure sockets for direct connection. 'Tee' connectors and tubing are supplied to allow many different connections. A syringe is supplied as a means of creating an adjustable pressure and vacuum.

1.2 H3a Apparatus

The H30 apparatus is supplied complete with the TecQuipment H3a 'Calibration of a Pressure Gauge' apparatus (also shown in Figure 1). This uses a precision Bourdon type pressure gauge with a clear dial so that its internal workings can be studied. Inside the gauge, the Bourdon tube is rigidly held at one end. When pressure is applied to the gauge, the tube straightens and moves. This movement is transferred through a mechanical system that gives proportional movement of the dial around the graduated scale. The range of the gauge depends on the type and thickness of the material used for the Bourdon tube.

The H3a apparatus includes a set of weights and a weight platform to apply a known pressure to the Bourdon scale to show its operation and for the calibration experiment.



1.3 Installation and Preparation

When you receive the apparatus, check all parts against the PACKING CONTENTS LIST. If any items are missing, carefully re-check among the packing materials.

H3a Apparatus

Set out the apparatus on a level worktop and remove the piston from the H3a apparatus. It is delivered lightly oiled, so do not clean the oil off until the unit is used. Fill the cylinder with water, and tilt the unit to remove any trapped air in the transparent tube, it will help if you gently 'tap' it. A small amount of air in the system will not affect the experiment or results. Top up the water and insert the piston into the cylinder, allow any air and excess water to discharge through the top hole of the cylinder. Allow the piston to settle.

H30 Apparatus

To fill the vertical and inclined manometers of the main unit, insert the funnel (supplied) into the open end of each tube and pour in water (suitable colour may be added to the water to improve clarity). Use the pipe clamps (supplied) to clamp the short pipes at the back of the apparatus, so that water does not leak out of the pressure sockets. Fill each manometer to half way.

Note: It may be necessary to tap the manometer tubes while you fill them, to allow trapped air to escape.

1.4 Routine Care and Maintenance

After use, wipe the units with a dry cloth. Drain the H3a unit and dry the piston and cylinder with a lint free cloth. Lightly oil the piston and refit it to the cylinder.

Important - Always oil the piston before you replace it in the cylinder for storage.

If the piston becomes seized in the cylinder, apply a penetrating oil to the inlet and outlet, allow time for the oil to soak thoroughly. Wait for 3 to 4 hours and then use a twisting action to remove the piston. **Do not** attempt to clean the piston or cylinder with any harsh abrasive. Use only a mixture of powdered chalk and oil to remove any discoloration.

SECTION 2.0 Experiment Procedure

Figure 2 The H3a 'Calibration of a Pressure Gauge' Apparatus

2.1 Calibration of a Pressure Gauge

a) Record the cross-sectional area and the mass of the plunger (piston) and the weight platform. The details are written on the label fixed to the apparatus.

b) Create a blank table of results similar to Table 1.

c) Ensure the apparatus is level.

			Increasing Pressure		Decreasing Pressure	
Mass added to piston	Total mass on piston (M)	Actual Pressure (P)	Gauge Reading	Gauge Error	Gauge Reading	Gauge Error
kg	kg	kN/m^2	kN/m^2	kN/m^2	kN/m^2	kN/m^2

Table 1 Blank Results Table for Calibration Experiment

d) Add the weights (masses) to the weight platform in approximately eight increments up to a maximum of 5.2 kg. ***Do not exceed 5.2 kg***. Always load the masses gradually, do not drop then onto the platform. Record the pressure gauge reading as each mass is added. To prevent the piston sticking, rotate the piston gently as each mass is added.

e) Remove the masses in the reverse order as you added them. Record the pressure gauge reading as you remove each mass.

f) From your results, calculate the actual pressure (P) and total mass (M) as described in Section 3. Plot graphs of the gauge pressure against actual pressure, and gauge error against actual pressure.

2.2 Pressure and Vacuum Measurement

The syringe (supplied) has a nozzle that fits into any of the pressure sockets (see Figure 3).

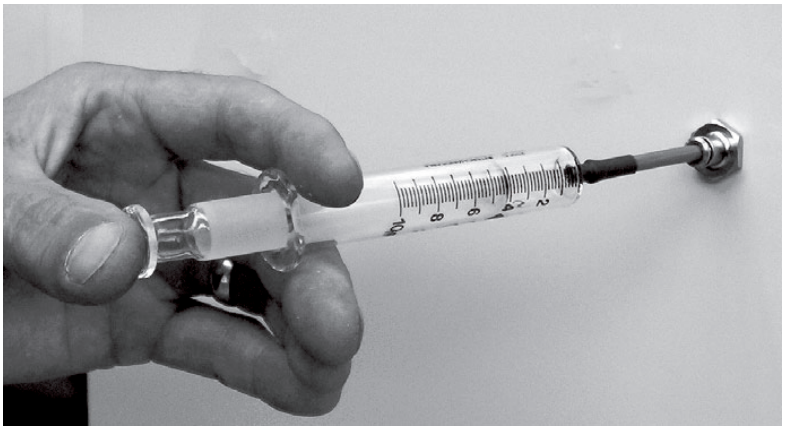


Figure 3 The Syringe Nozzle Fits into any of the Pressure Sockets.

Note; Never apply pressure to the Vacuum Gauge. It will be damaged.

a) Create a blank results table, similar to Table 2.

b) For pressure tests, extend the syringe fully before you connect it to the pressure sockets.

c) For vacuum tests, press the syringe piston in fully before you connect it to apparatus pressure sockets.

d) For accurate comparison and to save time, you may use the 'Tee' pieces and spare pipes (supplied) to connect a pressure or vacuum gauge and a manometer at the same time.

e) Make sure that the nozzle of the syringe is firmly connected.

f) Slowly move the syringe in steps to create pressure gauge changes of 50 mm H_2O. At each step, record the change in both the gauge reading and the two manometer levels at the same time. Monitor the manometer levels so that water is not spilt.

   Note: the pressure in the left hand tube of each manometer is termed P_1, the right hand tube is termed P_2.

g) From your results, calculate the 'adjusted' readings for each manometer as described in Section 3.

h) Plot a graph of the adjusted manometer readings against the pressure gauge readings. The slope of the graphs will show the error on either the Bourdon gauge or the manometer.

Pressure							Vacuum						
Pressure Gauge	Inclined Manometer			Vertical Manometer			Vacuum Gauge	Inclined Manometer			Vertical 'U' tube manometer		
mm H_2O	P_1 mm H_2O	P_2 mm H_2O	Adjusted (mm H_2O)	P_1 mm H_2O	P_2 mm H_2O	Δmm H_2O	mm H_2O	P_1 mm H_2O	P_2 mm H_2O	Adjusted (mm H_2O)	P_1 mm H_2O	P_2 mm H_2O	Δmm H_2O
0							0						
50							-50						
100							-100						
150							-150						
200							-200						
250							-250						
300							-300						
350							-350						
400							-400						

Table 2 Blank Results Table for Pressure and Vacuum Measurement

SECTION 3.0 Calculations

3.1 Calibration of a Pressure Gauge Experiment

The actual hydrostatic pressure (P) in the system due to a mass of M kg (including the piston and platform mass) applied to the piston is given by:

$$P = \frac{M \times 9.81}{A} \times 10^{-3} \text{ kN/m}^2$$

Where:

A = Piston area (in m^2).
M = Mass of Piston (plunger) + Platform + Weights (in kg)
P = Pressure (in N/m^2)

3.2 Pressure and Vacuum Measurement Experiment

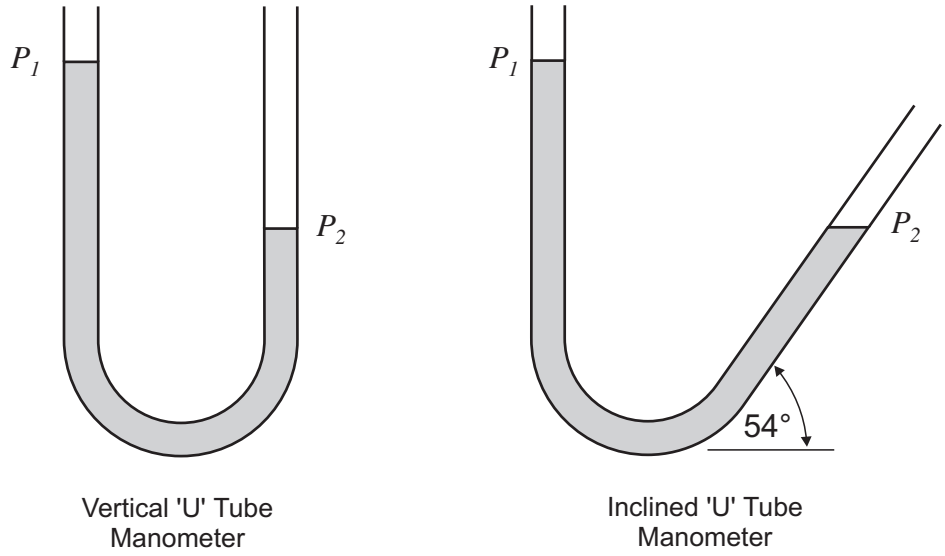


Figure 4 Layout of Manometers

The manometer readings must be 'adjusted' by simple maths and trigonometry to give actual readings. They record a *pressure difference* and so the level of one tube must be subtracted from the other to give actual pressure. One limb of the inclined manometer is set at an angle of 54° (see Figure 4), so this needs additional calculation to give actual readings.

$$P_g = P_u = P_v$$

$$P_u = P_1 - P_2$$

$$P_v = P_1 - P_2 \sin 54$$

Where:

P_g = Gauge pressure (in mmH_2O);
P_u = Vertical manometer pressure (in mmH_2O)
P_v = Inclined manometer pressure (in mmH_2O)

SECTION 4.0 Discussion Of Results

4.1 Errors in a Bourdon Type Gauge

Two different kinds of error may normally be expected in a Bourdon type gauge:

1) The possibility of hysteresis, friction and backlash. This will give smaller gauge readings when the pressure is increasing than when it is decreasing. Typically, the gauge tested on the H3a will have an error in the range of 1 kN/m^2 of the entire range, which is acceptably small.

2) Error due to incorrect marking of the scale. This error increases to a maximum of around 2.5% of the full scale reading. This is acceptably small for many engineering purposes although gauges with an error of only 0.5% of the full scale reading are available.

4.2 Errors in a Manometer

Manometers have an error due to inaccuracies in manufacturing the scale and user error in reading the level of water.

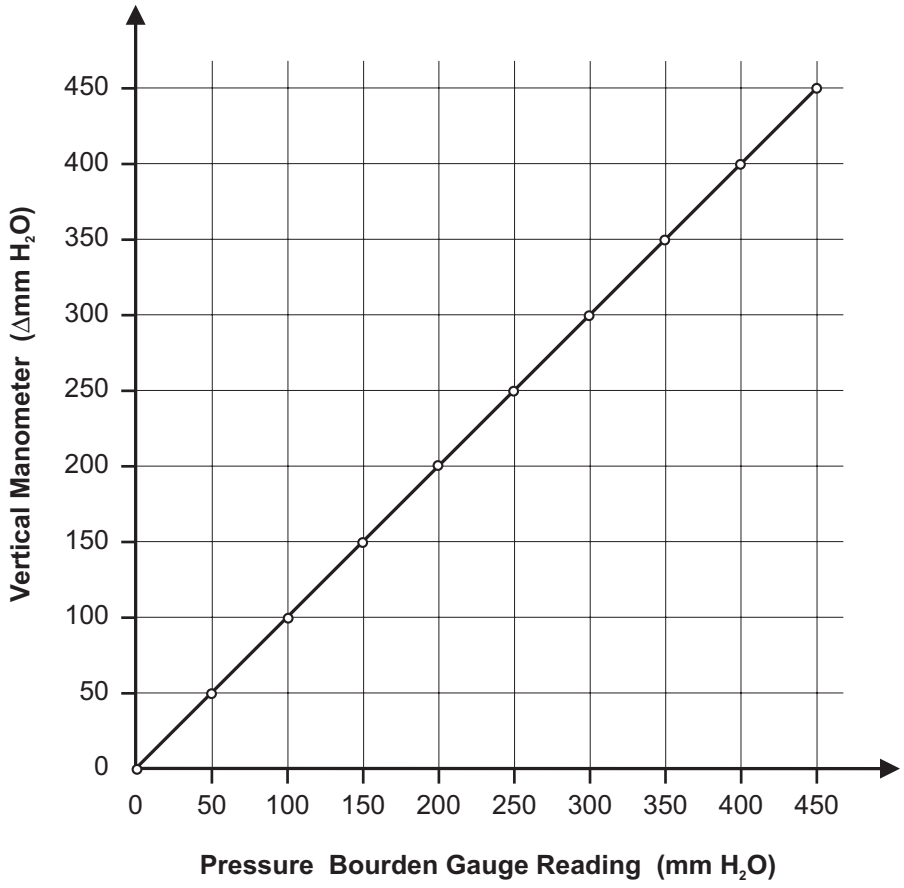


Figure 5 Typical Calibration Graph of the Vertical Manometer 'adjusted' Reading Against the Pressure Gauge Reading.

SECTION 5.0 Questions For Further Discussion

a) Could the apparatus be improved? How?

b) No correction has been made to the results for the difference in elevation of the piston of the dead weight tester and of the pressure gauge. If the centre of the gauge were 200 mm higher than the base of the piston, should a correction be made and, if so, how large would it be?

c) What alterations to the dimensions of the piston of the H3a would you suggest if it were used to calibrate a gauge having a full scale reading of 3500 kN/m^2 using the same weights?

SECTION 6.0 Spare Parts and Customer Care

6.1 Spare Parts

Refer to the Packing Contents List for any spare parts supplied with the apparatus.

If you require technical assistance or spares, please contact your local TecQuipment agent, or contact TecQuipment direct.

To assist us in processing your request quickly and efficiently, when requesting spares please include the following:

- Your name
- The full name and address of your college, company or institution
- Your email address
- The TecQuipment product name and product reference
- The TecQuipment part number (if known)
- The serial number
- The year of purchase (if known)

Please provide us with as much detail as possible about the parts you require and check the details carefully before contacting us.

If the product is no longer under warranty, TecQuipment will send you a price quotation for your confirmation.

6.2 Customer Care

We hope you find our products and manuals satisfactory. If you have any questions, do not hesitate to contact our Customer Care department immediately.

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