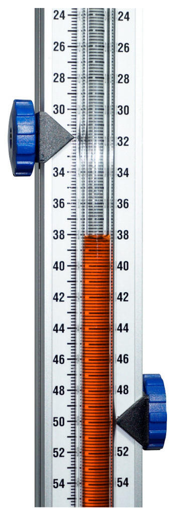
Boyle's Law Apparatus

High Pressure

Filler and air connection on the reservoir



Dual pointers to recall two column heights

MF0360-001 Boyle's Law – High Pressure

Description:

The apparatus consists of:

- 1x Base, tank, 400kPa gauge and column assembly.
- 1x Bottle of coloured fluid for half-filling the tank.
- 1x Small efficient dual piston pump as used for pumping tyres.
- 1x Nylon line from reservoir to pump.
- 1x Storage bracket for pump

Length: 160mm	Width: 160mm	Height: 730mm	Packed Weight: 2kg

All Moulded Leak Tight Construction:

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The Pump:

The compact air pump provides dual pressures because it has dual piston sizes.

With the lever flat down (as pictured) or levered up straight, both pistons are used and pressure up to 250kPa is easy to pump.

For higher pressures up to 400kPa the smaller piston is used. Move the lever as far as it can move and the higher pressures will be easier to achieve using only the smaller piston

Features:

The IEC High Pressure Boyle's Law apparatus does not use mercury and therefore is much safer in the classroom. It is compact and well engineered. A large pressure gauge scaled up to 400kPa and a protective plastic tube over the glass column adds to the safety. Industrial style pressure fittings for leak tight operation and long service life. To remove the nylon air line from the fitting, the top edge of the fitting is simply pressed down.

The combination filler cap and inlet fitting to the tank contains its own check valve so the air cannot escape after pumping up the pressure. The air pressure is permitted to escape slowly by slightly unscrewing the filler cap. A small valve permits air removal from the top of the glass tube.

The Pressure pump is stored conveniently in a plastic bracket fixed to the vertical column.

The Scale:

The scale should be positioned so that the zero line is between the black 'O'ring seal line and the underside of the metal sealing pin that protrudes into the glass at the upper end.

Using the Apparatus:

Boyle's law states that the relationship between the pressure of a gas and its volume while it is held at a constant temperature is '**PV = k' pressure by volume is a constant.** Most Boyle's law instruments operate at very low pressures and a mercury column is used to compress the gas volume and also to measure the pressure created.. This instrument proves Boyle's law at a higher pressure than normal and the use of mercury is not required..

A small reservoir is connected to a vertical glass tube which is sealed at the upper end. This heavy wall high pressure glass tube is protected against damage inside a plastic tube and, if the glass breaks during an experiment, the glass and the liquid is held captive. A scale is fitted behind the glass tube so the volume of the air space can be measured proportionately. The reservoir contains water based colored fluid and, when the reservoir is pressurised by a small air pump, the fluid is forced up the glass tube and can be seen to compress the air inside the tube.

The reservoir upper face has an air fitting, a filler cap and a pressure gauge. The kit includes a nylon line to connect from the reservoir to the outlet of the pump.

The Coloured Fluid:

Remove the filler cap and notice the rubber seal on the underside. Pour the water based coloured fluid into the reservoir up to about one third full and replace the filler cap and screw down firmly.

Connecting the Air Pump:

The pump outlet fitting is connected to the reservoir's inlet fitting by firmly pushing in the nylon line. When pressed into the fitting, the line will automatically seal perfectly, or pump can remain connected.

To remove the nylon line, press down the edge of the fitting while gently pulling on the nylon line. As the pump is operated, the pressure gauge indicates the rise in pressure and the colored fluid will be seen to rise up the glass tube and compress the residual air.

When pressurised, the "check valve" built into the reservoir stops any air escaping back to the pump. The pressure gauge should read steady and not fall back.

Caution:

The reservoir must not be pressurised beyond the maximum reading on the pressure gauge.

Initial Filling of the Fluid Reservoir:

To prepare a new instrument for operation, unscrew the knurled cap on the top of the reservoir, pour in the colored fluid supplied up to about one third full.

Caution:

The fluid should NOT completely fill the reservoir. A level around one third full is sufficient for the equipment to operate correctly.

Then open the valve on the top of the glass tube to allow the fluid to rise in the tube and relax at the same height as in the reservoir. Now replace the filler cap securely and close the vent at the top of the glass tube.

Performing an Experiment:

- If the pump is disconnected, attach the pump to the reservoir with the nylon line. Push the nylon line firmly into the fittings and they will automatically seal.
- Operate the pump so that the pressure in the reservoir is increased to near maximum on the gauge. The fluid should be seen to rise in the glass tube as the pressure increases. A perfect seal will be made by the "check valve" built into the reservoir and the reservoir should not lose air pressure.
- Using the scale provided, measure the length of the air column from the underside of the metal sealing pin in the upper end of the glass tube to the surface of the liquid. Note pressure gauge reading. By slightly unscrewing the filler cap on the reservoir, release the air very slowly from the reservoir to reduce the pressure by about 40kPa and again take readings of the length of the air column and air pressure. Repeat until the pressure is zero.

The Calculations:

Boyle's Law: Pressure x Volume = a constant (k) $PV = k$ or $V = k/P$

Therefore, volume varies in proportion to the inverse of the pressure. Thus a graph of the gas volume (Y axis) to the inverse of the pressure (X axis) should be a straight line with a slope of 'k'.

Remember that air pressure around us already is pressurised to 100kPa (one atmospheric pressure) and the gauge will be reading zero kPa. Therefore any gauge reading must have 100kPa added to it to be the true gas pressure.

Increase the initial gas pressure to 400kPa on the gauge (add 100kPa to call it 500kPa in your data). Very slightly open the filler cap to reduce the pressure in 40kPa intervals. Make note of the air column length (which is proportional to air volume). When the pressure is exhausted and the gauge shows zero kPa, call this 100kPa and note the air column length for your data.

Plot a graph of air column length (Y axis) to inverse of air pressure (X axis).

The X axis should read from 0.002 (which is the reciprocal of 500kPa. which is 400kPa + the initial 100kPa), up to 0.01 (which is the reciprocal of 100kPa initial gas pressure). The Y axis should read from zero up to 700mm.

The graph of the gas volume plotted against the inverse of the total gas pressure should be a straight line and should prove the linear relationship between volume and the inverse of pressure as stated in 'Boyle's Law' of gases. The slope of the line (dY/dX) should be the value of the constant 'k'.

A different approach: Boyle's Law: $V_1P_1 = V_2P_2 = k$, therefore $V_1/V_2 = P_2/P_1$.

Take two different gauge pressures (add the 100kPa initial atmospheric pressure in each case) and take the two corresponding volumes or lengths of air columns. See if the law is true.

Designed and manufactured in Australia