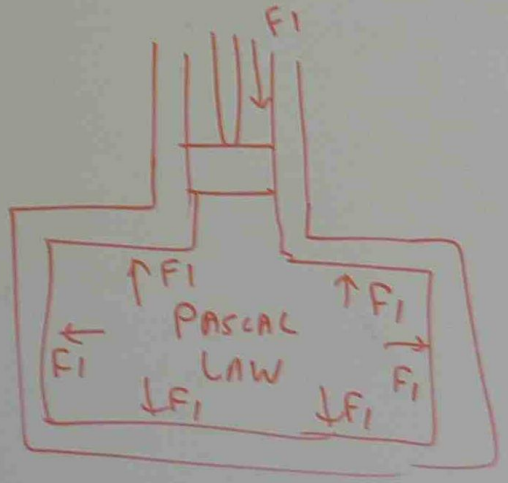
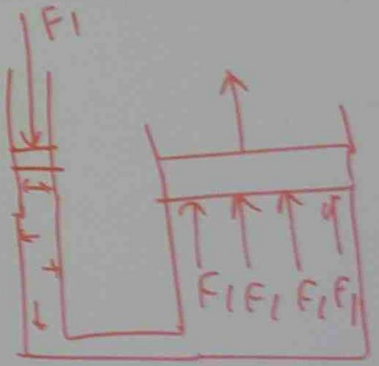
PHYSICAL PRINCIPLES IN PNEUMATICS

LIQUIDS AND GASES FLOW FREELY AND FOR THAT REASON BOTH ARE CALLED FLUIDS.

A FLUID IS DEFINED AS A SUBSTANCE WHICH CHANGES IN SHAPE EASILY AND ADAPTS TO SHAPE OF IT'S CONTAINER.





AS AIR PRESSURE AND FLUID PRESSURE ARE WIDELY USED IN INDUSTRIAL PROCESS CONTROL SYSTEMS, THE MEASUREMENT OF PRESSURE, FORCE, MASS AND DENSITY IS IMPORTANT ASPECT OF INDUSTRIAL PROCESS CONTROL SYSTEM.

TRANSMISSION of FORCE BY FLUIDS

WHEN ONE END OF A BAR OF SOLID MATERIAL IS STRUCK, THE MAIN FORCE OF THE BLOW IS TRANSMITTED STRAIGHT THROUGH THE BAR TO OPPOSITE END.

IT IS TRANSMITTED AT ANGLES DIFFERENT TO THE DIRECTION OF BLOW

FLUID

THE FORCE SPREADS IN DIFFERENT DIRECTIONS WITH EQUAL MAGNITUDE IN FLUID.

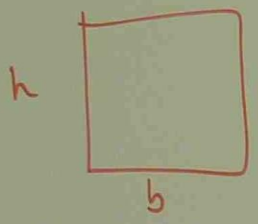
$$\text{PRESSURE} = \frac{\text{FORCE}}{\text{AREA}}$$

FORCE = PRESSURE × AREA

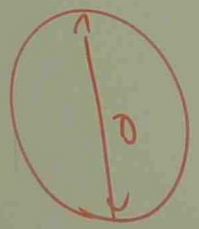
FORCE (UNIT – NEWTON (N))

PRESSURE (UNIT – PASCAL (OR) N/m^2)

AREA (UNIT – m^2)



$A = b \times h$



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

FORCE = MASS × ACCELERATION

$F = m \times a$

F = (N)

m = (kg)

a = (m/s^2)

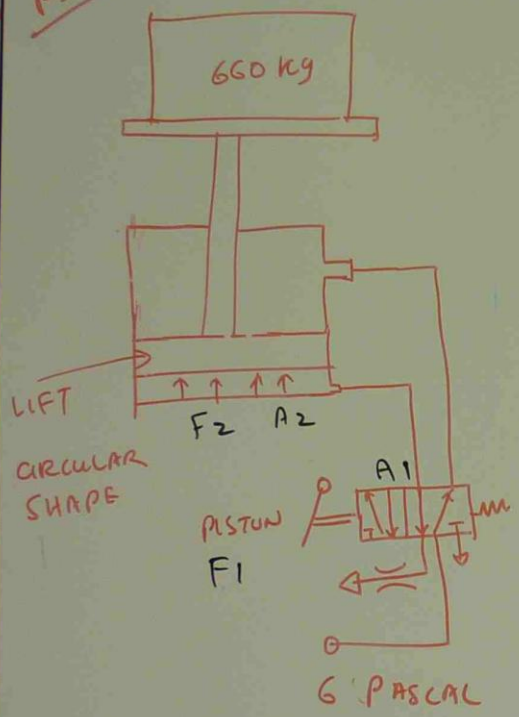
GRAVATIONAL FORCE = $m\ g$

m = MASS (kg)

g = GRAVITY ($9.8 m/s^2$)

INDUSTRIAL HYDRAULIC LIFT

Pb



IN ABOVE DIAGRAM, IF FORCE 1 N IS APPLIED TO PISTON WITH 0.5 m^2 C.SA, TO LIFT 660 kg, WHAT WILL BE THE DIAMETER OF LIFT.

PRESSURE 1 (PISTON) = PRESSURE 2 (LIFT)

$$P_1 = P_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\frac{1\ N}{0.5} = \frac{660 \times 9.81}{A_2}$$

$$A_2 \times 1 = 0.5 \times 660 \times 9.81$$

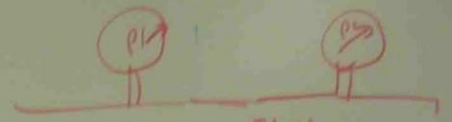
$$A_2 = 330 \times 9.81 = 3237.3\ m^2$$

$$\frac{\pi}{4} D^2 = 3237.3$$

$0.7854\, D^2 = 3237.3$

$D = \sqrt{\frac{3237.3}{0.7854}}$

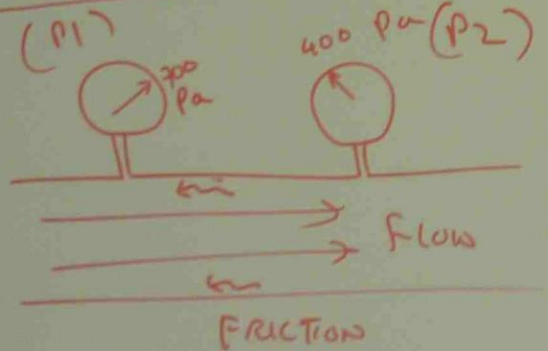
$= 64\ m$



$P_1 = P_2$

UTILIZE PRESSURE GAUGE TO MEASURE THE PRESSURE AT THE VARIOUS POINT ON PIPE LINE

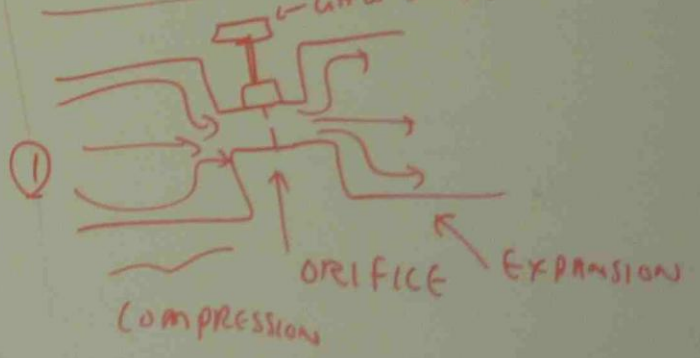
FLOW AND PRESSURE DROP

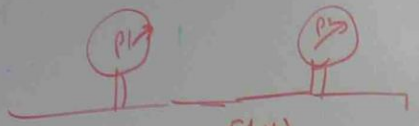


$P_1 > P_2$

FRICTION DEPENDS ON SURFACE ROUGHNESS, SHAPE, NO. OF BENDS AND AREA OF THE PIPE.

FLOW AND PRESSURE CONTROL BY GATE VALVE AND ORIFICE

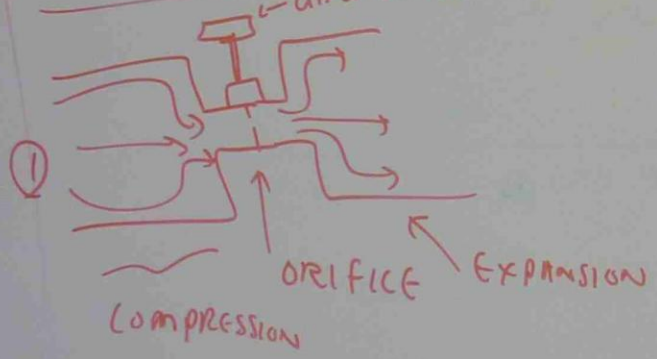




$P_1 = P_2$

UTILIZE PRESSURE GAUGE TO MEASURE THE PRESSURE AT THE VARIOUS POINT ON PIPE LINE

FLOW AND PRESSURE CONTROL BY GATE VALVE AND ORIFICE



BOYLES' + CHARLES' COMBINED LAW

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

P_1, P_2 = PRESSURE (PASCAL (OR) N/m^2)

V_1, V_2 = VOLUME (m^3)

T_1, T_2 = TEMPERATURE ('K)

$T = 273 + t$ $\quad t = c$

Boyles' + Charles' combined law

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

P_1, P_2 = pressure (pascal (or) N/m^2)

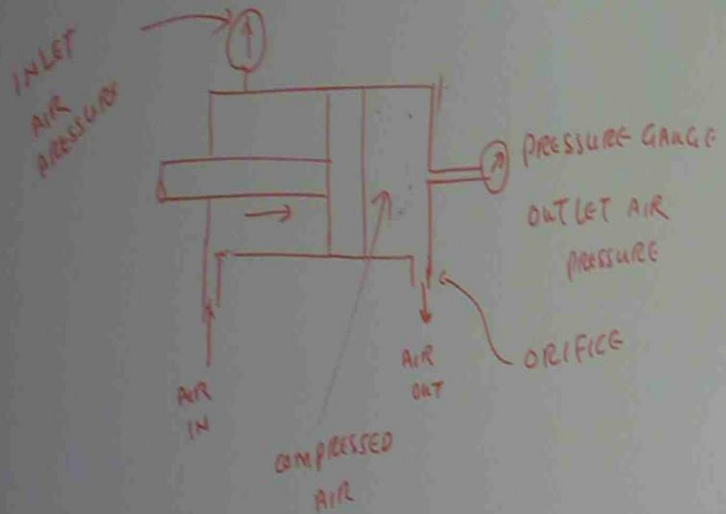
V_1, V_2 = volume (m^3)

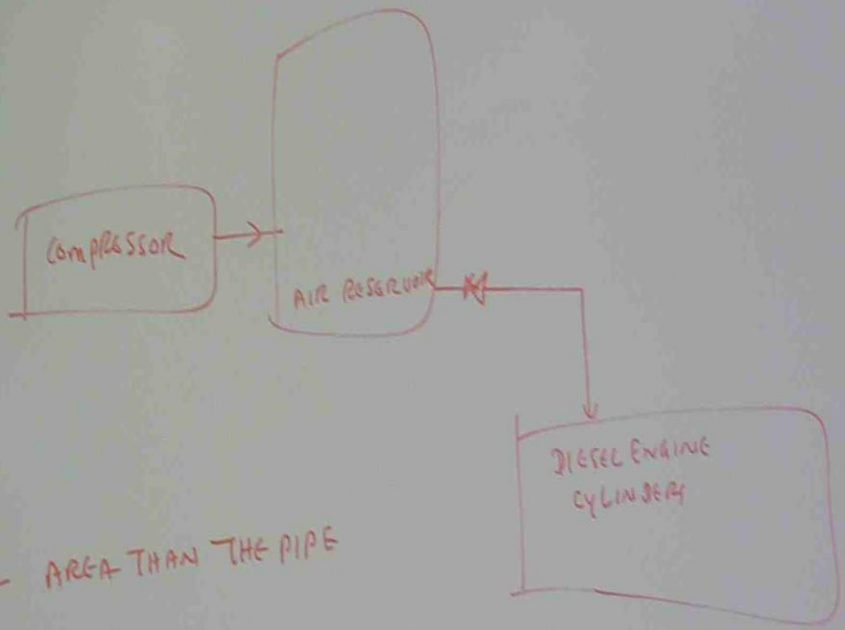
T_1, T_2 = temperature ('K)

$T = 273 + t \quad t = c$

When the gas or fluid is compressed (or) expanded in a particular point, it's pressure, volume and temperature will change. The use of material is required to be appropriate to such change.

FLOW THROUGH AN ORIFIC TO ATMOSPHERE





AN ORIFICE IS A HOLE WITH LESS CROSS SECTIONAL AREA THAN THE PIPE OR CAVITIES TO WHICH IT IS FITTED.

THE ORIFICE IS GENERALLY USED TO CONTROL FLOW (OR) TO CREATE A PRESSURE.

WHEN COMPRESSED AIR IS DISCHARGED THROUGH AN ORIFICE TO ATMOSPHERE, THE DISCHARGE ORIFICE IS EITHER SONIC (SPEED OF SOUND) (OR) SUB SONIC (SLOWER THAN SPEED OF SOUND).

THE SPEED DEPENDS ON TWO FACTORS

- THE SHAPE OR TYPE OF ORIFICE
- AND
- THE PRESSURE DIFFERENTIAL ACROSS THE ORIFICE.

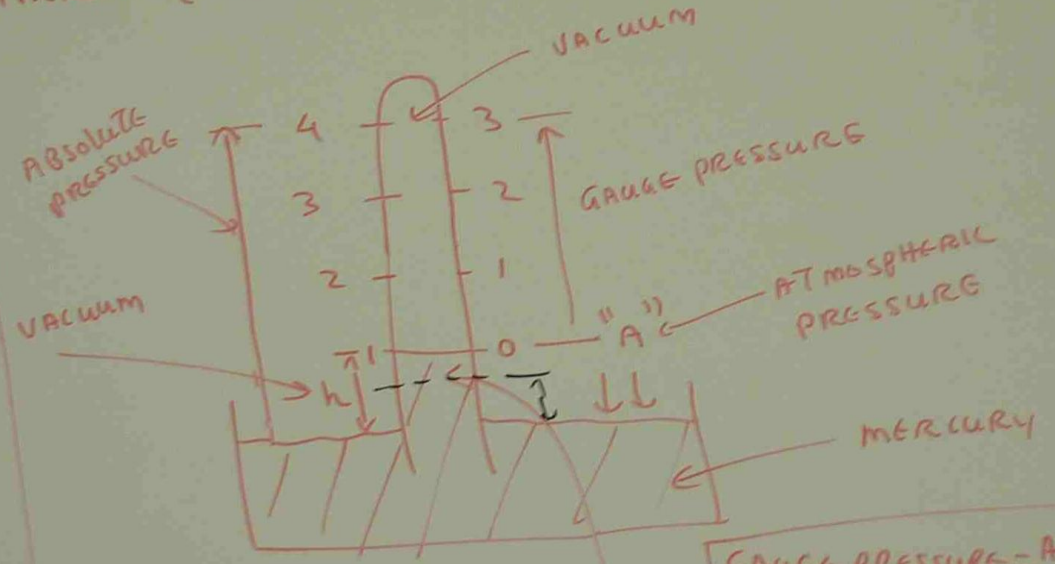
FREE AIR

FREE AIR AND COMPRESSED AIR

78% NITROGEN + 20% OXYGEN + 1% ARGON + 1% OTHER GASES

ATMOSPHERIC PRESSURE = 101.3 kPa

MERCURY BAROMETER IS UTILIZED TO MEASURE ATMOSPHERIC PRESSURE



GAUGE PRESSURE = ABSOLUTE PRESSURE − ATMOSPHERIC PRESSURE

VACUUM PRESSURE

ANY PRESSURE BELOW NORMAL ATMOSPHERIC PRESSURE IS TERMED VACUUM PRESSURE. IT CAN BE MEASURED WITH SAME BAROMETER.

AT ABSOLUTE ZERO PRESSURE, THE MERCURY COLUMN IN VACUUM WILL DISAPPEAR ENTIRELY.

GAUGE PRESSURE VERSUS ABSOLUTE PRESSURE

MOST PRESSURE GAUGES USED IN PNUEMATIC SYSTEMS HAVE A PRESSURE CALIBRATION BASED ON ATMOSPHERIC PRESSURE.

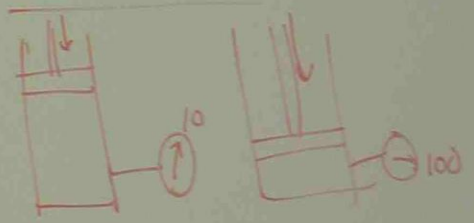
PRESSURE IN LIQUID

THE DEPTH DETERMINES THE PRESSURE

H ∝ PRESSURE

H = DEPTH

PRESSURE & COMPRESSION



1001- SET

1002 - PRE

1004 - FL

1005 - T

1006 -

IC PRESSURE IS

MEASURED WITH

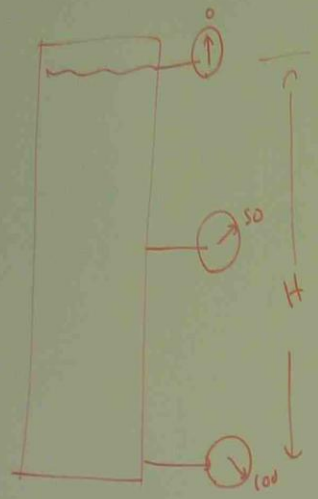
CURY COLUMN

RESSURE

NUEMATIC

RATION BASED

PRESSURE IN LIQUID

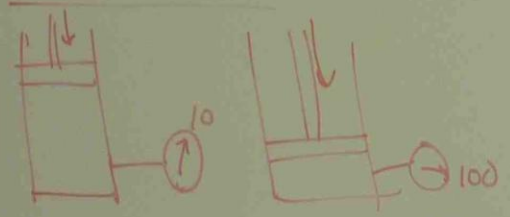


THE DEPTH DETERMINES THE PRESSURE

$H \propto$ PRESSURE

H = DEPTH

PRESSURE & COMPRESSION



I001 - SET UP TRANSDUCER & SENSING DEVICES

I002 - PRESSURE MEASUREMENT

+

I004 - FLOW MEASUREMENT

I005 - TEMPERATURE MEASUREMENT

I006 - PROCESS CONTROLLER

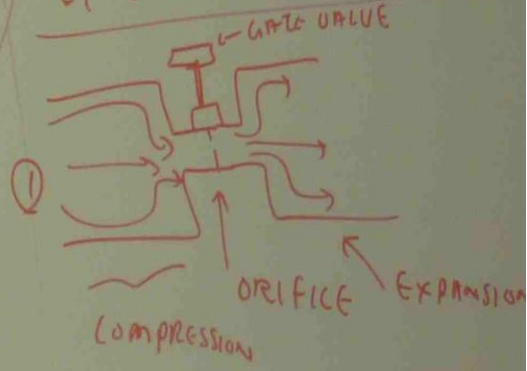
TRANSMITTER

CONVERTER.

$P_1 = P_2$

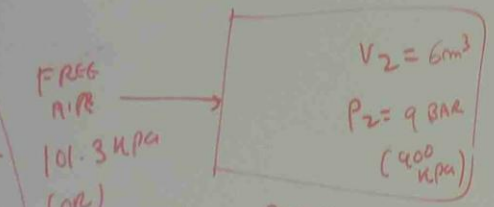
UTILIZE PRESSURE GAUGE TO MEASURE THE PRESSURE AT THE VARIOUS POINT ON PIPE LINE

FLOW AND PRESSURE CONTROL BY GATE VALVE AND ORIFICE



- SET UP TRANSDUCER & SENSING DEVICES
- PRESSURE MEASUREMENT
- FLOW MEASUREMENT
- TEMPERATURE MEASUREMENT
- PROCESS CONTROLLER TRANSMITTER CONVERTER.

Pa AN AIR RESERVOIR WITH A VOLUME OF $6\,m^3$ MUST BE FILLED WITH COMPRESSED AIR TO A MAXIMUM PRESSURE of 900 KPa (9 BAR). CALCULATE THE VOLUME OF FREE AIR. (1 BAR = 100 KPa)



$$P_1 V_1 = P_2 V_2$$

$$1.013 \times V_1 = 9 \times 6$$

$$V_1 = \frac{9 \times 6}{1.013} = 69.3\,m^3$$

Pb A BATHROOM WITH A GAS VOLUME of $0.3\,m^3$ AT A TEMPERATURE of $-14^{\circ}C$ IS HEATED TO A TEMPERATURE OF $90^{\circ}C$. WHAT IS THE INCREASED GAS VOLUME IF PRESSURE REMAINS CONSTANT.

$V_1 = 0.3\,m^3$

$T_1 = (t_1 + 273) = -14 + 273 = 259\,K$

$V_2 = ?$

$T_2 = 90 + 273 = 363\,K$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{0.3}{259} = \frac{V_2}{363}$$

$$V_2 = \frac{0.3 \times 363}{259} = 0.42\,m^3$$