PNEUMATIC CHARACTERISTICS AND APPLICATIONS
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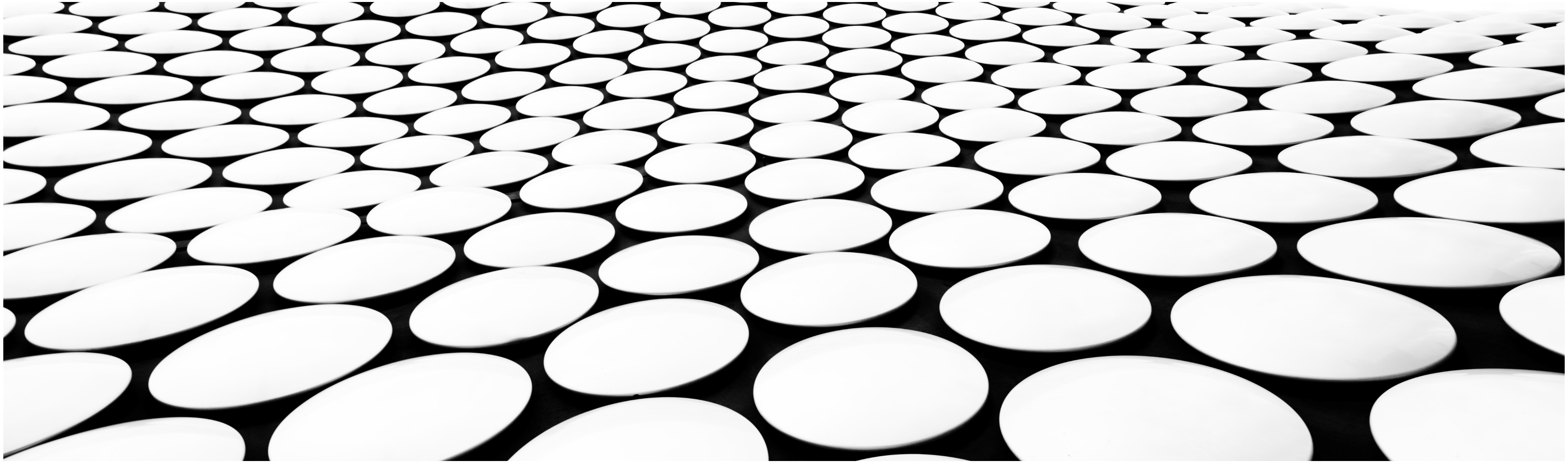


REVIEW OF THE PREVIOUS LECTURE

- Fluid power definition.
- Example applications of fluid power
- Advantages/disadvantages of fluid power
- Hydraulic vs pneumatics
- Advantages/disadvantages of pneumatics and hydraulics
- Example of fluid power

OUTLINE

- Why pneumatics?
- Industrial applications of pneumatics
- Structure and signal flow of pneumatic systems
- Physical fundamentals
- Characteristics of air: Boyle-Mariotte's Law
- Gay-Lussac law
- General gas equation
- Flow vs. pressure drop

WHY PNEUMATICS?

The pneumatic cylinder has a significant role as a linear drive unit, due to its:

- Relatively low cost.
- Ease of installation.
- Simple and robust construction.
- Ready availability in various sizes and stroke lengths.

WHY PNEUMATICS?

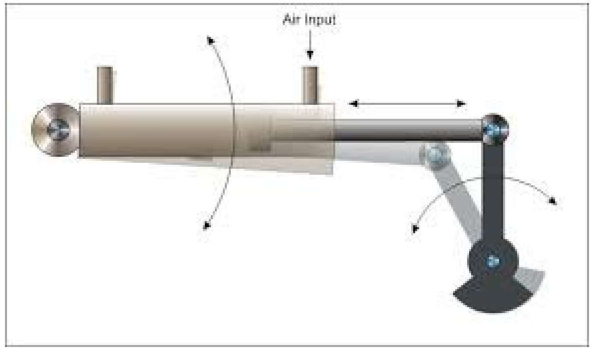
The pneumatic cylinder has the following general characteristics:

- Diameters 2.5 to 320 mm
- Stroke lengths 1 to 2000 mm
- Available forces 2 to 45000 N at 6 bar
- Piston speed 0.1 to 1.5 m/s

Note: every 1 bar= 14.5 psi = 100 kPa

Pneumatic components can easily perform the following types of motion:

- Linear
- Swivel
- Rotary



INDUSTRIAL APPLICATIONS OF PNEUMATICS

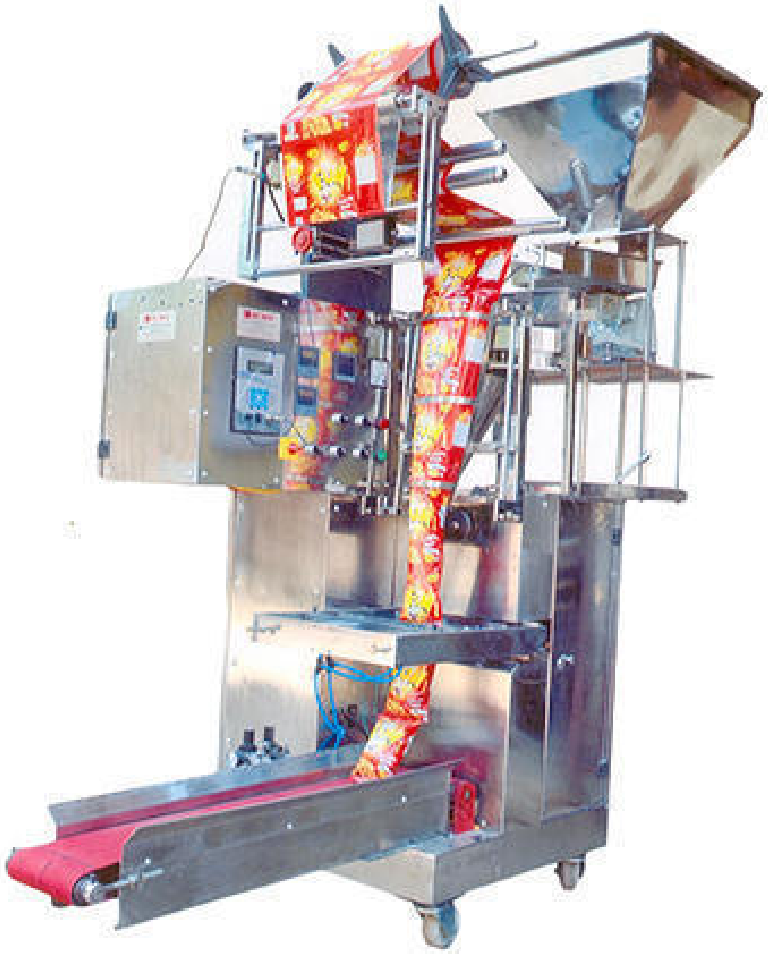
General methods of material handling:

- Clamping
- Shifting
- Positioning
- Orienting
- Branching of material flow

INDUSTRIAL APPLICATIONS OF PNEUMATICS

General applications:

- Packaging
- Filling
- Metering
- Locking
- Driving of axes
- Door or chute control
- Transfer of materials
- Turning and inverting of parts
- Sorting of parts
- Stacking of components
- Stamping and embossing of components

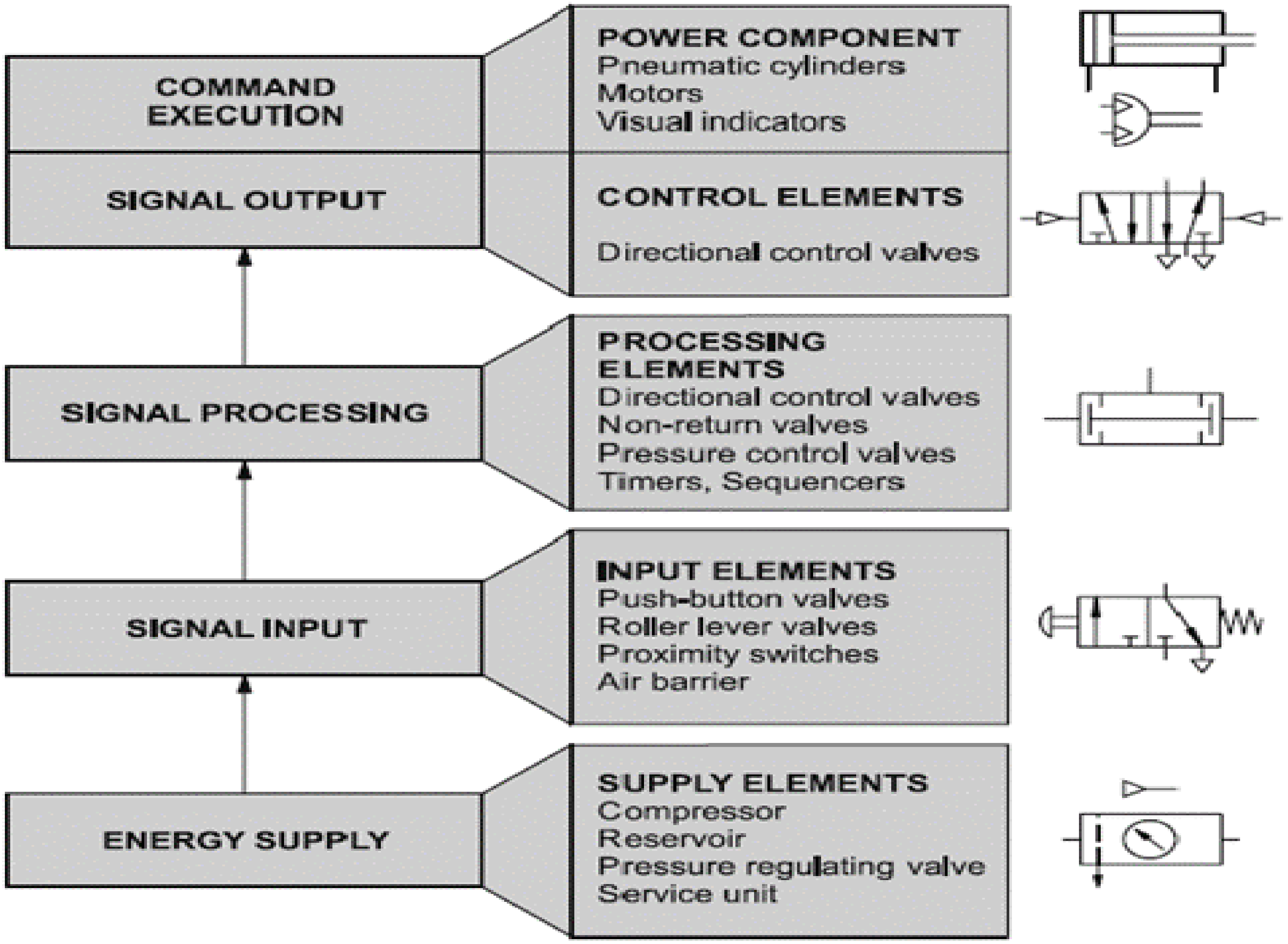


INDUSTRIAL APPLICATIONS OF PNEUMATICS

Machining and working operations:

- Drilling
- Turning
- Milling
- Sawing
- Finishing
- Forming
- Quality control

STRUCTURE AND SIGNAL FLOW OF PNEUMATIC SYSTEMS



PHYSICAL FUNDAMENTALS

Air is an abundant gas mixture with the following composition:

- Nitrogen approx. 78 vol. %
- Oxygen approx. 21 vol. %
- It also contains traces of carbon dioxide, argon, hydrogen, neon, helium, krypton and xenon.

Basic units	Quantity	Symbol	Units
	Length	L	Meter (m)
	Mass	m	Kilogram (kg)
	Time	t	Second (s)
	Temperature	T	Kelvin (K, 0 °C = 273.15 K)

Derived units	Quantity	Symbol	Units
	Force	F	Newton (N) = 1 kg • m/s^2
	Area	A	Square metre (m^2)
	Volume	V	Cubic metre (m^3)
	Flowrate	q_v	(m^3/s)
	Pressure	p	Pascal (Pa) 1 Pa= 1 N/m^2 1 bar = 10^5 Pa

PHYSICAL FUNDAMENTALS

- Newton's Law: Force = mass • acceleration

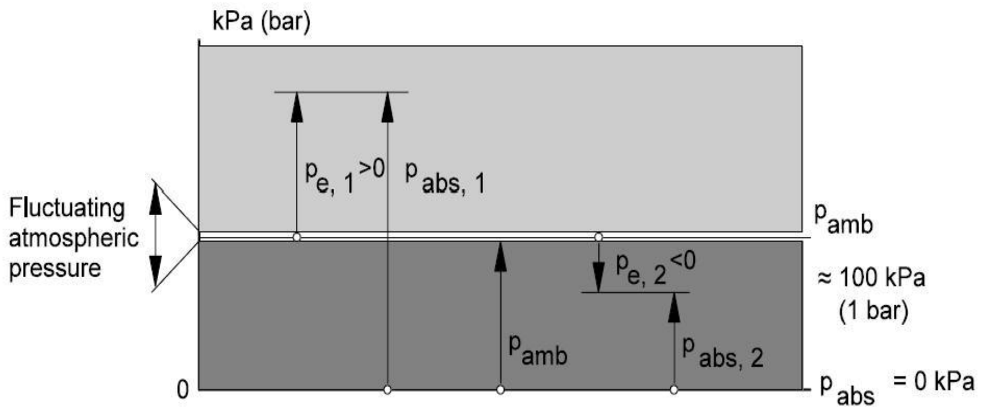
$F = m \cdot a$

where a is replaced by the acceleration due to gravity g = 9.81 m/s2.

- Pressure: 1 Pascal is equal to the constant pressure on a surface area of 1 m2 with the vertical force of 1 N (Newton).

$F = P \cdot A$

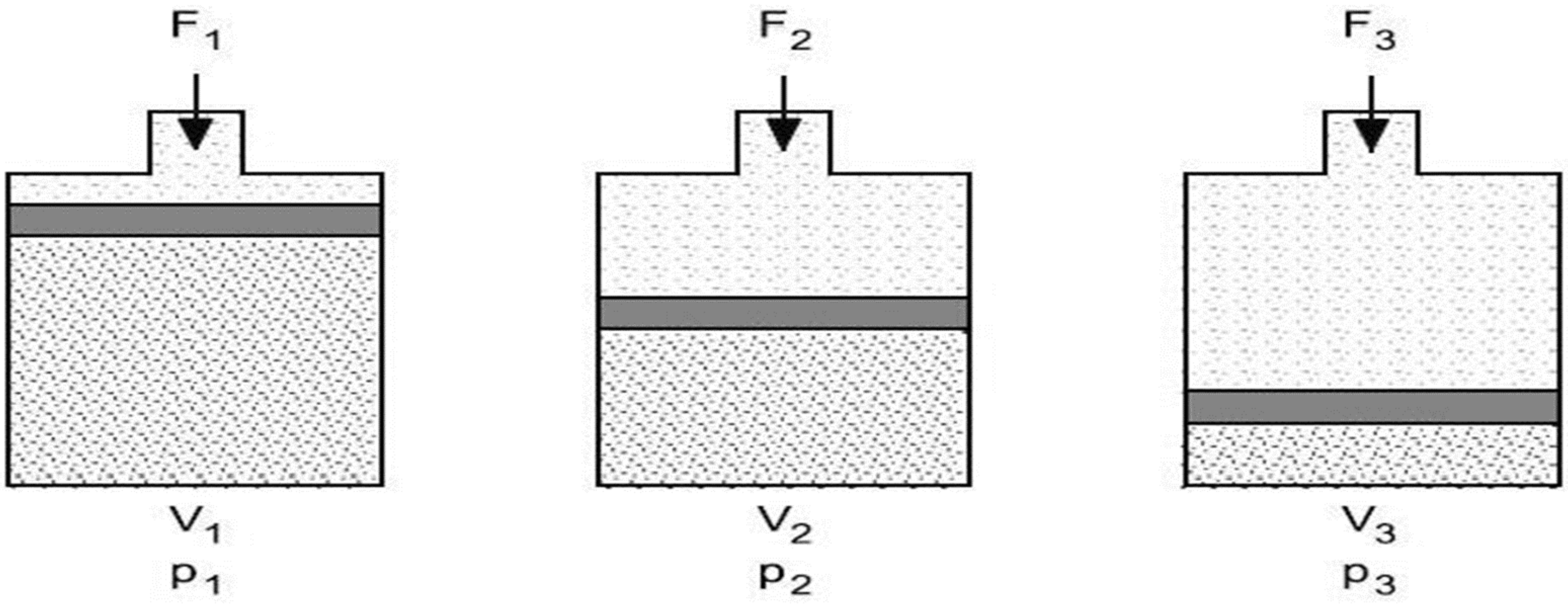
$$p_e = p_{abs} - p_{amb}$$



PHYSICAL FUNDAMENTALS

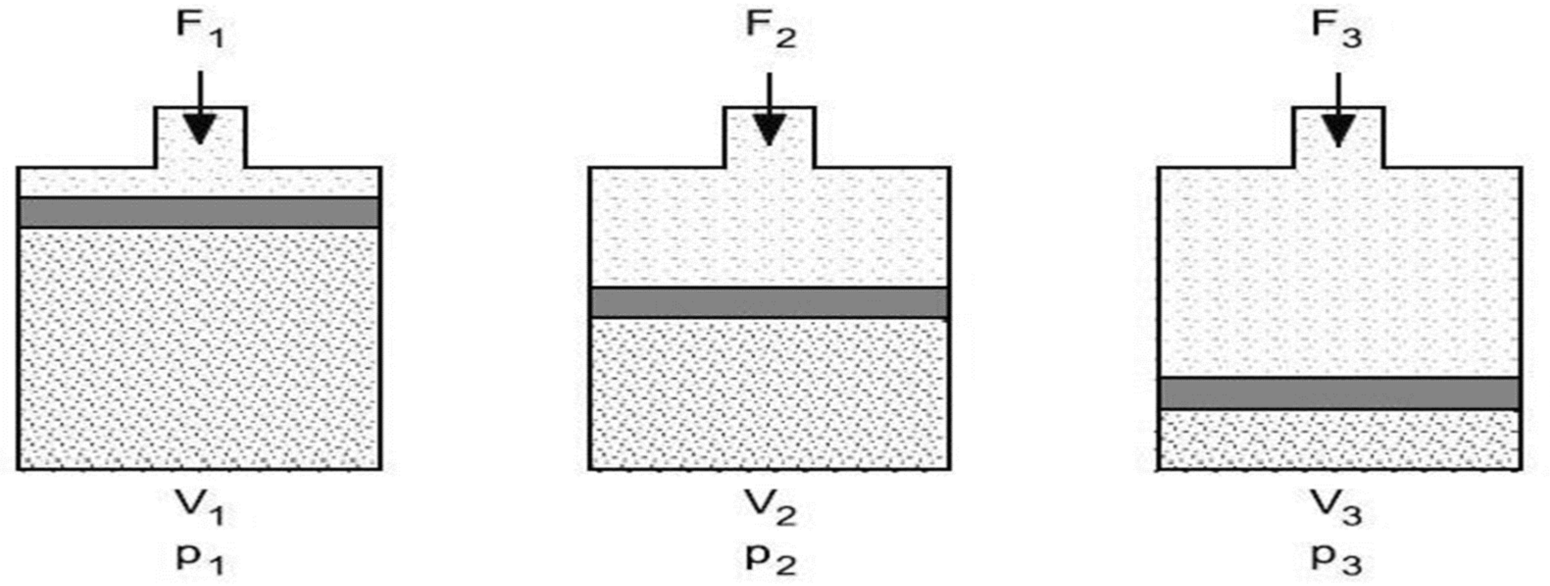
- Generally, in pneumatics all data concerning air quantity refers to the so-called standard state.
- According to DIN 1343, the standard state is the status of a solid, fluid or gaseous substance defined by standard temperature and pressure.
- Standard temperature $T_n = 273.15$ K, $t_n = 0$ °C
- Standard pressure $P_n = 101325$ Pa = 1.01325 bar

CHARACTERISTICS OF AIR
BOYLE-MARIOTTE'S LAW



$$p_1 \bullet V_1 = p_2 \bullet V_2 = p_3 \bullet V_3 = \text{Constant}$$

CHARACTERISTICS OF AIR
BOYLE-MARIOTTE'S LAW



The pressure of a gas tends to increase as the volume of the container decreases.

$$p_1 \bullet V_1 = p_2 \bullet V_2 = p_3 \bullet V_3 = \text{Constant}$$

EXAMPLE CALCULATION

Air at atmospheric pressure is compressed by an air compressor to 1/7th the volume. What is the gauge pressure of the air assuming a constant temperature process ?

Atmospheric pressure=101.325 kPa.

$p_1*v_1=p_2*v_2$

$101.325_*v1=p2*(1/7)*v1$

$P_2= 101.325/(0.1428)$

P2=709.558 kPa

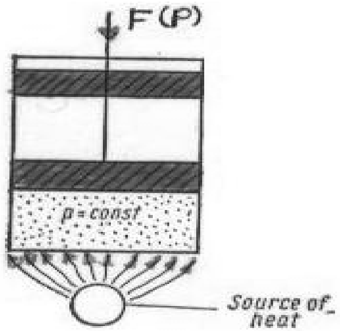
P2 is total pressure

$P2_{gague}= p_{total}-p_{atm}$

$P2_{gauge} = 709.558$ kPa-101.325 kPa

$P2_{gauge} = 608.233$ kPa

GAY-LUSSAC LAW



$$\frac{V_1}{V_2} = \frac{T_1}{T_2}$$ V_1 = Volume at T_1, V_2 = Volume at T_2

or

$$\frac{V}{T} = \text{Constant}$$

The volume change ΔV is:

$$\Delta V = V_2 - V_1 = V_1 \bullet \frac{T_2 - T_1}{T_1}$$

The following applies for V_2:

$$V_2 = V_1 + \Delta V = V_1 + \frac{V_1}{T_1}(T_2 - T_1)$$

The pressure of a given mass of gas varies directly with the absolute temperature of the gas, when the volume is kept constant

EXAMPLE CALCULATION:

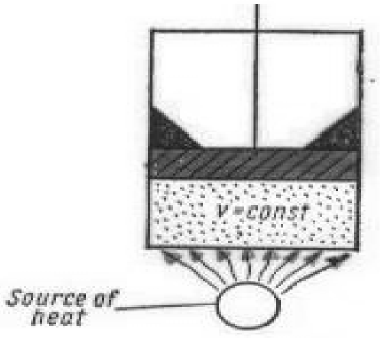
Volume of 0.8 m^3 air at temperature $T_1 = 293$ K (20 ^{0}C) are heated to $T_2 = 344$ K (71 ^{0}C). How much does the air expand?

$$\frac{V1}{V_2} = \frac{T1}{T2}$$

$$\frac{0.8}{V_2} = \frac{293}{344}$$

$$V_2=(0.8*344)/293=0.93\ m^3$$

V2= 275.2/293 =0.939 m3



$$\frac{p_1}{p_2} = \frac{T_1}{T_2}$$

or

$$\frac{p}{T} = \text{Constant}$$

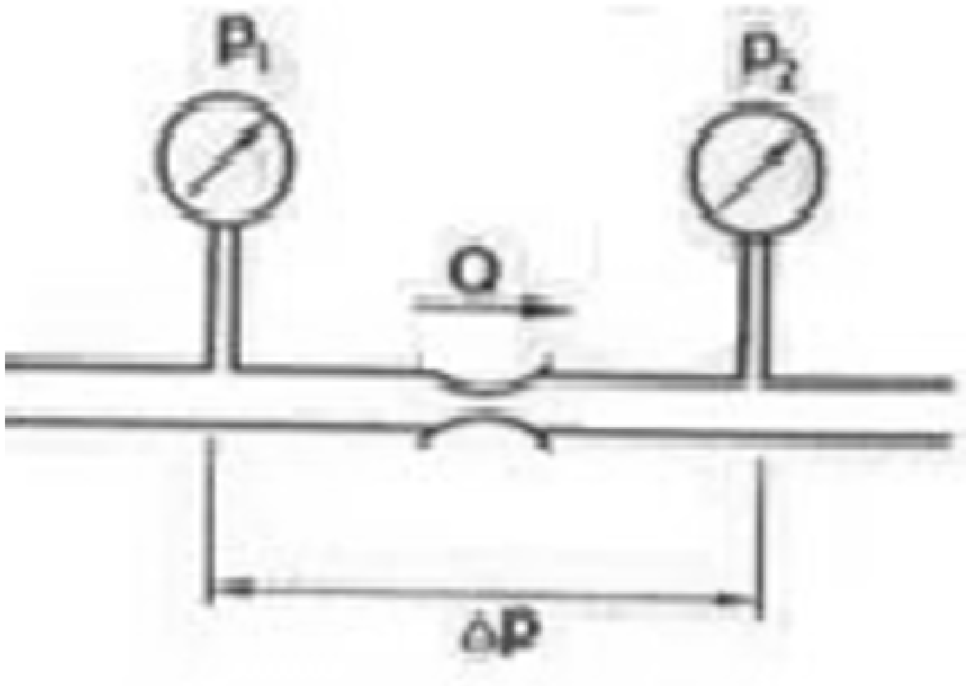
GENERAL GAS EQUATION

$$\frac{p_1 \bullet V_1}{T_1} = \frac{p_2 \bullet V_2}{T_2} = \text{Constant}$$

This general gas equation results in the previously mentioned laws, if one of the three factors p, V or T is kept constant in each case.

- Pressure p constant : isobar changes
- Volume V constant : isochore changes
- Temperature T constant : isothermal changes

FLOW VS. PRESSURE DROP



$$q = \frac{\Delta p}{R}$$