SAIOH Tutorial

Ventilation 1 – pressures and basic air flow calculations

Acknowledgement

- This tutorial was provided by SAIOH as an assessment support aid for prospective candidates.
- The tutorial is free to use and share for learning and knowledge improvement for candidates preparing to sit SAIOH registration assessments.
- Please ensure that you acknowledge SAIOH as the author and source of this material.

Pressure

- For air to flow there must be a pressure difference and air will flow from the higher pressure to the lower pressure

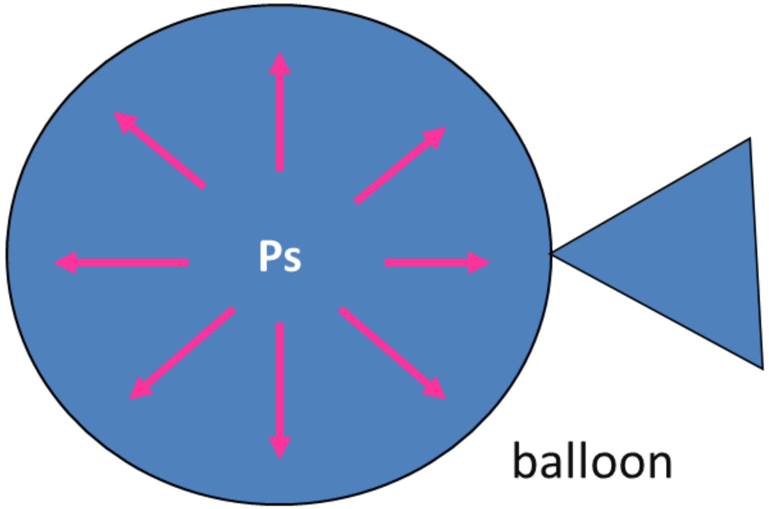
- Pressure is considered to have two forms:
  - static pressure (P_s)
  - velocity pressure (P_v)

With the sum of these being total pressure (P_t).

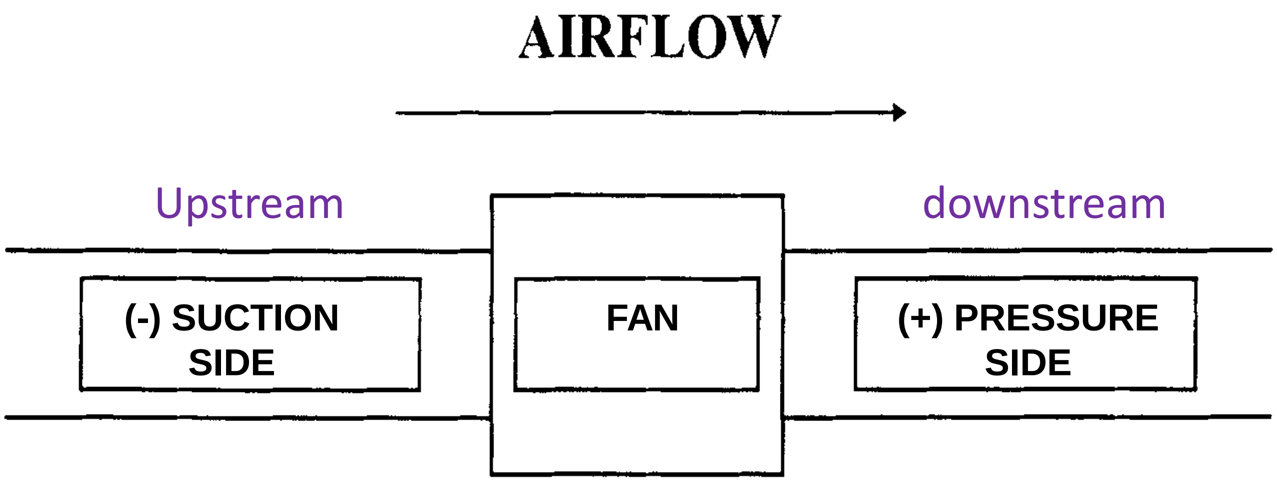
Static Pressure

- Static pressure is defined as the pressure exerted in all directions by a fluid that is stationary

- If the fluid is in motion (as is the case in a ventilation system), static pressure is measured at 90° to the direction of the flow so as to eliminate the influence of movement (ie: velocity)



Static Pressure (Cont)



Can be both positive and negative depending if it is measured on the discharge or suction side of a fan

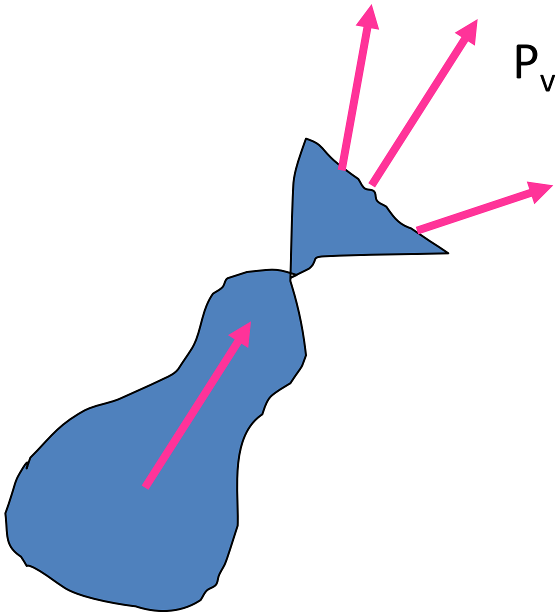
Velocity Pressure

- Defined as that pressure required to accelerate air from zero velocity to some velocity and is proportional to the kinetic energy of the air stream

- In simple terms, velocity pressure is the kinetic energy generated in a ventilation system as a result of air movement

Velocity Pressure

- Is the pressure due to air moving
- acts in the direction of the air movement/ flow
- Always positive



Velocity Pressure (cont)

$$\mathbf{P_v = \rho \frac{v^2}{2}}$$

ρ = Density of air (kgm^{-3})

v = Air velocity ms^{-1}

P_v = Velocity pressure (Pa ie Nm^{-2})

Velocity Pressure (cont)

If standard temperature and pressure conditions are in existence, i.e.:

ρ = 1.2 kg m^{-3}

Then

P_v = $0.6\ v^2$

Total Pressure - P_t

- Algebraic sum of static and velocity pressure at any point
- May be +ive or –ive depending on flow direction

$$P_t = P_s + P_v$$

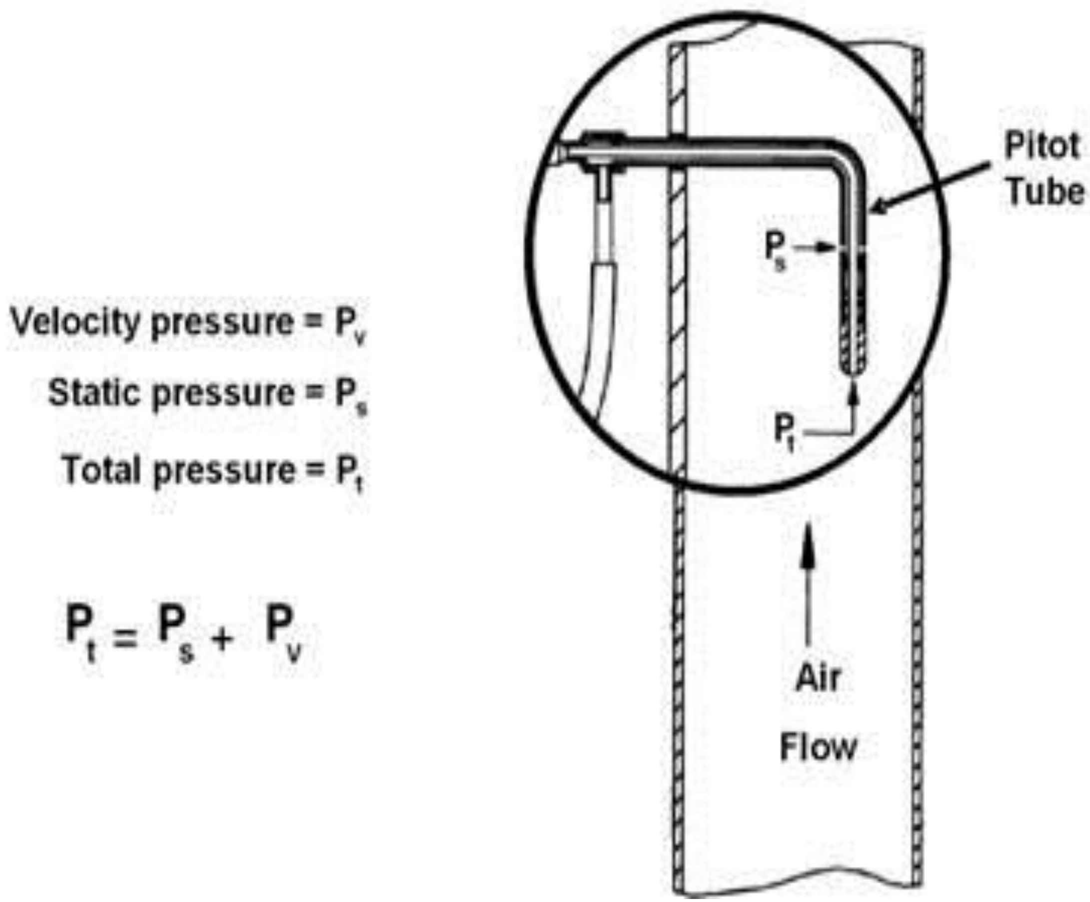
P_t = total pressure

P_s = Static pressure

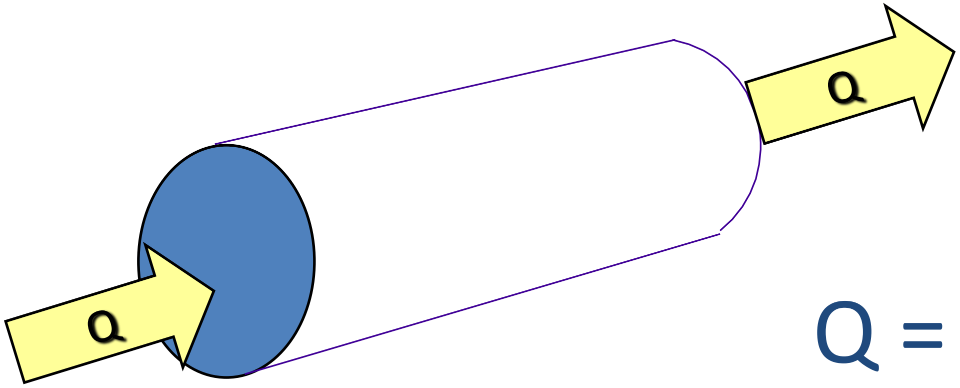
P_v = Velocity pressure

All in Pascal’s, Pa (Nm^{-2})

Relationship is: $P_t = P_s + P_v$



Volume and Mass



$Q = VA$

When a quantity of air is moving within a ventilation system the volumetric flow rate is a product of the velocity of the air and the cross-sectional area of the system through which it is flowing.

Volume flow

- The volume of air passing through a duct is calculated by:

$$Q = V \times A$$

Where:

- Q = Quantity of air flow in m^3s^{-1}
- V = Air velocity measure across the duct in ms^{-1}
- A = cross sectional (face) area of the dust (or hood) in m^2

Calculating the area of round ducts

$$A = \pi r^2$$

Example: a duct is measured at 250mm diameter, what is its area in m^2

Step 1 – convert mm to m = 0.25m diameter

Step 2 – calculate the radius = 0.25 x 0.5 = 0.125

$$A = \pi\ 0.125^2$$

Using the calculator press the following buttons:

0.125 [x^2] x [π] = 0.049 m^2

Calculating the area of round ducts

$$A = \pi r^2$$

Calculate the cross sectional areas (m^2) for the following size round ducts:

100mm	125mm	150mm	200mm	225mm	275mm	300mm

Calculating the area of round ducts

$$A = \pi r^2$$

Calculate the cross sectional areas (m^2) for the following size round ducts:

100mm	125mm	150mm	200mm	225mm	275mm	300mm
0.008	0.012	0.018	0.031	0.040	0.059	0.071

Calculating the area of Square or rectangular ducts

multiply the width by the height (remember to convert units to m)

$$A = W \times H \text{ (in m)}$$

Calculate the cross sectional area (m^2) for a duct of W 200mm and H 300mm

$$A = 0.20 \times 0.30 = 0.06 \text{ m}^2$$

Calculating the area of Square or rectangular ducts

multiply the width by the height (remember to convert units to m)

Calculate the cross sectional area (m^2) for the following ducts

W 100mm H 300mm	W 400mm H 200mm	W 600mm H 300mm	W 1500mm H 1000mm

Calculating the area of Square or rectangular ducts

multiply the width by the height (remember to convert units to m)

Calculate the cross sectional area (m^2) for the following ducts

W 100mm H 300mm	W 400mm H 200mm	W 600mm H 300mm	W 1500mm H 1000mm
0.03	0.08	0.18	1.5

Calculating volume flow rates (m^3s^{-1})

$$Q = V \times A$$

The average velocity of air passing through a 150 mm diameter duct was measured at 12 ms^{-1}, what is the volume flow rate?

Step 1 calculate A = 0.018

Step 2 calculate Q = 12 x 0.018 = 0.22m^3s^{-1}

Calculating volume flow rates (m^3s^{-1})

Calculate the volume flow rates for the following situations:

17.5 ms^{-1} in a 250 mm diameter duct = ___________

22.2 ms^{-1} in a 125 mm diameter duct = ___________

13.7 ms^{-1} in a rectangular duct 125 x 250mm = ________

17.5 ms^{-1} in a rectangular duct 200 x 400mm = ________

Calculating volume flow rates (m^3s^{-1})

Calculate the volume flow rates for the following situations:

17.5 ms^{-1} in a 250 mm diameter duct = 0.86 m^3s^{-1}

22.2 ms^{-1} in a 125 mm diameter duct = 0.27 m^3s^{-1}

13.7 ms^{-1} in a rectangular duct 125 x 250mm = 0.43 m^3s^{-1}

17.5 ms^{-1} in a rectangular duct 200 x 400mm = 1.40 m^3s^{-1}

Calculating Velocity

- If Q = V x A - then it is possible to calculate velocity from a know quantity of air flowing through a system
- Rearrange the equation for this calculation?

Calculating Velocity

- If Q = V x A then it is possible to calculate velocity from a know quantity of air flowing through a system
- Rearrange the equation for this calculation?

$$V = \frac{Q}{A}$$

Exercise 1

If the velocity inside a circular duct with a diameter of 0.5 metre is $9.1ms^{-1}$, what is the volume flow?

Exercise 1- Answer

- First, determine the area of the duct

$$A = \pi r^2 \text{ (r= radius of duct)}$$

$$= 3.142 \times (0.25)^2$$

$$= 0.2 \text{ m}^2$$

- Now $Q = VA$

$$\text{So } Q = 9.1 \times 0.2$$

$$= 1.8 \text{ m}^3\text{s}^{-1}$$

Exercise 2

The face velocity at a booth (2 x 1.5 m) is 0.5 ms^{-1} and the duct from the booth is 0.4 m in diameter

- What is the volume flow through the system?
- What is the velocity in the duct?

Exercise 2

1st step calculate the areas of the booth and the duct:

for the booth A =

and the duct A =

Exercise 2

1^{st} step calculate the areas of the booth and the duct:

for the booth A = L x W 2 x 1.5 = $3m^2$

and the duct A = πr^2 (r= radius of duct)

$= 3.142 \times (0.20)^2$

$= 0.126\ m^2$

Exercise 2 - Answer

What is the volume flow through the system (hood)?

$$Q = vA$$

What is the velocity in the duct?

$$v = Q/A$$

Exercise 2 - Answer

What is the volume flow through the system?

$Q = vA$ $0.5 \times 3 = 1.5\ m^3s^{-1}$

What is the velocity in the duct?

$v = Q/A$

$V = 1.5/0.126$

$V = 11.9\ ms^{-1}$