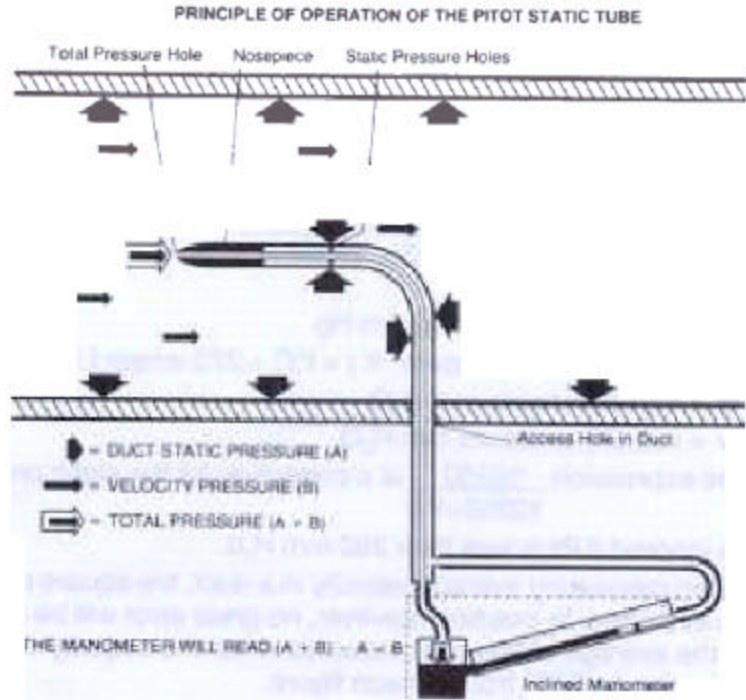


Flow velocity calculations

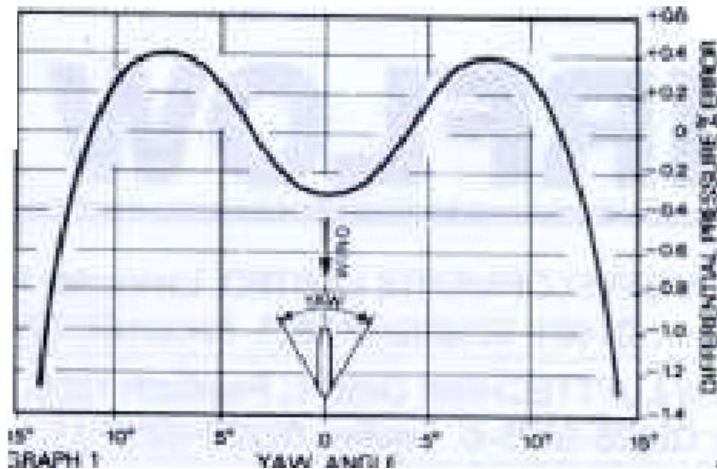
The diagram shows the basic principle of operation of a pitot tube. Here, it is used to measure air flow in a duct. An inclined manometer is used in the drawing to improve the resolution of the manometer when measuring low differential pressures with a standard unit. Modern electronic measuring devices make this unnecessary, and can measure pressure differences of 0.1 Pa (1μbar) without great difficulty.

One other advantage of the pitot tube over other measuring methods is that the hole in the duct need not be much larger than the diameter of the pitot tube itself. In most cases, there is an indicator fixed to the pitot to ensure that the tube is orientated correctly into the flow. Incorrect orientation will lead to an error in the reading as the diagram below shows. Typically, this can be kept below 5% in almost all



cases, ensuring accuracy and repeatability of readings at all times. The pitot tube is robust and simple to use, only the calculations can look formidable to anyone not used to them!

EFFECT OF YAW ANGLE ON PRESSURE READING



An error in alignment of the pitot tube will lead to a false reading as the graph shows. These effects should not be too large in most cases and can generally be ignored, providing readings are carried out with all due care. This principle is also used for the speed determination on aircraft and other similar applications where there is no convenient reference point for movement. Today,

these are checked by satellite navigation readings, but this is still the basic standard for such measurements in all fields of aviation. In cases where there are other extreme turbulences in the medium, an average of readings for a number of points is taken. The method of averaging is detailed below, although no mention is made of the standards used for deciding where to take the measurements. This is generally dictated by physical constraints in most cases.

The basic formula for calculation of velocity is:

$$V = 1.291 \sqrt{\frac{1013.25 \times T \times 100000}{B \times 293 \times 100000 + P_s} \times P_v}$$

Where:

V = velocity in ms^{-1}

B = local barometric pressure in mbar

T = absolute temperature in Kelvin ($\sim^\circ\text{C} + 273$)

P_s = static pressure in mbar

P_v = dynamic pressure in mbar

When calculating the average velocity in a duct, the square roots of the dynamic pressures should be averaged. In practice it is generally quite sufficient to take the square root of the average dynamic pressure, providing the individual readings do not vary by more than $\pm 25\%$ from the average.