USING THE MODELS TA465, PVM610, AND PVM620 TO MEASURE PRESSURE

APPLICATION NOTE AF-107 (A4)

Models TA465, PVM 610 and PVM 620 measure differential pressure, or in other words, the pressure difference between the two pressure ports. The (+) port connects to the higher pressure and the (-) port connects to the lower pressure (often ambient pressure). Using these instruments to measure differential pressure is like using a digital voltmeter: when the pressure is connected the same way the tubes are marked, the meter displays a positive number. When the pressure is reversed, the meter displays a negative number.

Although different terms are used to describe different types of pressure, we can think of all pressure as differential pressure. For instance, the term "absolute pressure" refers to the difference between an absolute vacuum and the pressure of interest. The absolute pressure of ambient air is known as barometric pressure.

NOTE:
The differential pressure sensor cannot measure barometric pressure. If you try to measure barometric pressure (which is approximately 400 inches of water, or 101 kPa) by connecting the (-) port of the instrument to an absolute vacuum, the pressure sensor inside the unit will be destroyed because it is only designed to measure ±10 inches of water (2.5 kPa).

Static pressure describes the difference between the pressure inside and outside a system, disregarding any motion in the system. For instance, when referring to an air duct, static pressure is the difference between the pressure inside and outside the duct, without taking into account pressure from any air flow inside the duct. Static pressure is often measured inside ducts in order to determine how hard the blower is working.

Models TA465, PVM 610, and PVM 620 are supplied with a static pressure tip that can be used for measuring static pressure. Attach the static pressure tip to a tube on the (+) port of the instrument. Keep the (-) port free so that it can measure ambient conditions. Make sure the static pressure tip is pointed directly into the airflow. If the static pressure in the duct is positive, the instrument will display a positive number. If the static pressure is negative, the instrument will display a negative number.

The static pressure can also be measured using a regular pitot tube as shown in Figure 1, below. A pitot tube is a tube within a tube. The inside tube is open to the air at the tip of the tube (total pressure), and the outside tube is open on the sides of the tube (static pressure). To measure static pressure with a pitot tube, you use only the static pressure port and ignore the total pressure port.

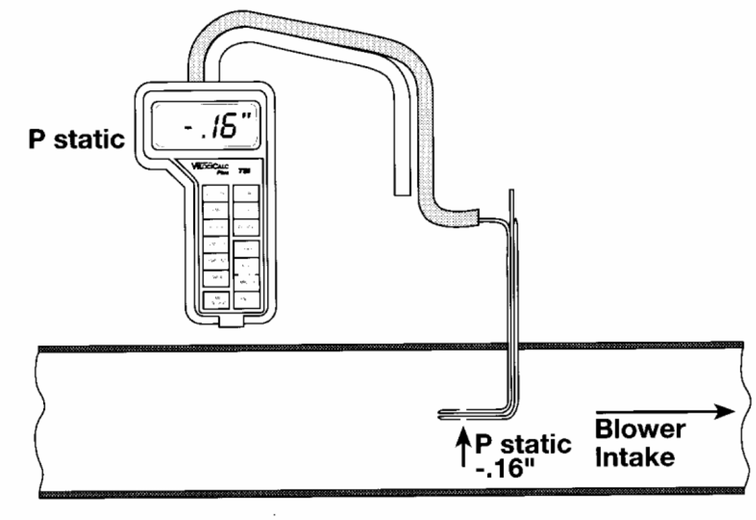

Figure 1: Measuring static pressure with pitot tube

The instrument can also be used for measuring velocity pressure (Velocity Pressure = Total pressure - Static Pressure) with a pitot tube and converting into air velocity. It is useful in locations where the thermal anemometer probe cannot be used. For instance, it may be desired to measure velocity in an exhaust stack, where high temperatures and high particle content could damage the velocity probe.

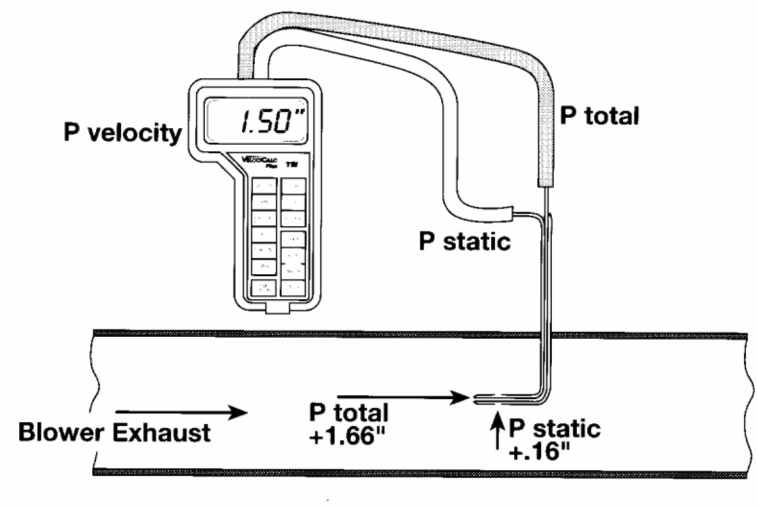

Figure 2: Measuring velocity pressure with a pitot-static tube

The front orifice of the pitot tube senses the total pressure, which is the static pressure in the duct plus the velocity pressure caused by air blowing into this orifice. By connecting the instrument to the pitot tube, you will get velocity pressure.

When the measurement conditions are close to standard conditions of 70°F (21.1°C) and 14.7 psia (29.92 in. mercury or 101.4 kPa), the following equations can be used with a pitot-static tube to compute velocity:

$$V_{ft/min} = 4004.4\sqrt{P_V}$$

Where:

$V_{ft/min}$ = velocity in feet per minute
P_v = velocity pressure measured by the instrument in inches of water

$$V_{m/s} = 40.76\sqrt{P_V}$$

Where:

$V_{m/s}$ = velocity in meters per second
P_v = velocity pressure measured by the instrument in kPa

If the measurement conditions are substantially different from standard conditions of 70°F (21.1°C) and 14.7 psia (29.92 in. mercury or 101.4 kPa), the following equation can be used to calculate standard velocity:

$$V_{std\ ft/min} = 1687.6\sqrt{PP_V/(T + 459.67)}$$

Where:

$V_{std\ ft/min}$ = velocity in standard feet per minute
I = barometric pressure in inches of mercury
P_v= velocity pressure measured by the instrument in inches of water
T = flow temperature in °F

$$V_{std\ m/s} = 25.4\sqrt{PP_V/(T + 273.15)}$$

Where:

$V_{std\ m/s}$= velocity in standard meters per second
P = barometric pressure in millimeters of mercury
P_v = velocity pressure measured by the instrument in kPa
T = flow temperature in °C

It is important to note that the equations above give standard velocity, which is velocity corrected to standard conditions. Standard velocity is the same measurement unit that the thermal anemometer velocity probe of the instrument indicates, and is a measure of the mass of the moving air. Most people are used to computing actual velocity (not corrected to standard conditions) using the pitot-static tube, however. The following equations can be used to calculate actual velocity when conditions are different than standard conditions of 70°F (21.1°C) and 14.7 psia (29.92 in. mercury or 101.4 kPa):

$$V_{ft/min} = 1096.7\sqrt{P_V/d}$$

Where:

$V_{ft/min}$ = velocity in actual feet per minute
P_v = velocity pressure measured by the instrument in inches of water
d = density of dry air in pounds per cubic foot

To compute d, the density of dry air in pounds per cubic foot:

d = 1.325 Pb / (T + 459.67)

Where:

P_b = barometric pressure in inches of mercury
T = flow temperature in °F

$$V_{m/s} = 44.63\sqrt{P_v / d}$$

Where:

$V_{m/s}$= velocity in actual meters per second
P_v = velocity pressure measured by the instrument in kPa
d = density of dry air in kg/m^3

To compute d, the density of dry air in kg/m^3:

$d = 0.4638\ Pb / (T + 273.15)$

Where:

Pb = barometric pressure in mm. of mercury
T = flow temperature in °C

Some pitot-static tube manufacturers have slide-rule type devices that make the corrections for you automatically. The AIRFLOW Instruments models will do these calculations for you, provided you enter the test temperature and barometric pressure.

It is important to remember that if temperature or pressure is substantially different from standard conditions, the difference between actual velocity and standard velocity could likewise be substantial. This means that when using the actual velocity equations with the pitot-static tube, the result will be different than the velocity probe reading (standard velocity). Airflow Instruments recommends using the standard velocity equations for the pitot-static tube because standard velocity measures the mass of the moving air. This defines the air's heat carrying capacity and its combustion oxygen content.

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