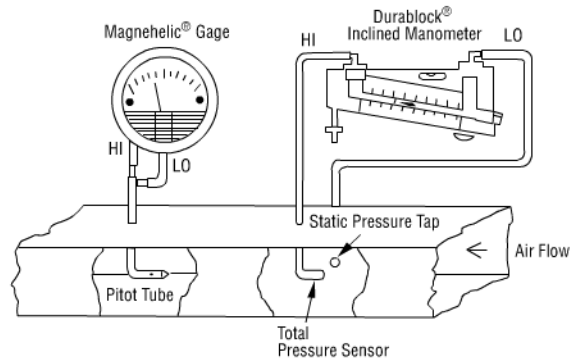


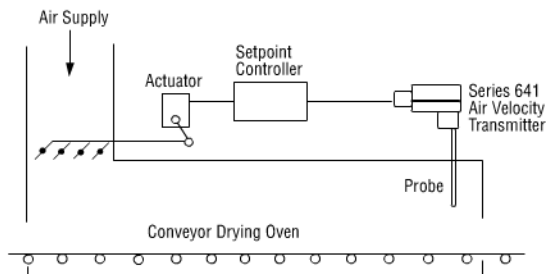
Dwyer® transmitter signals precise air velocity adjustments to computer-controlled variable-speed fan motor.

In variable air volume (VAV) HVAC systems, a computerized control provides precise adjustment of air volume to meet changing system needs with maximum energy efficiency. The Dwyer® Series 641 has an optional LED display for local indication of air flow. The LED display provides a quick, visual acknowledgement of proper system performance. The computer reacts to any change in velocity by signaling the motor control to increase or decrease fan speed to maintain the required velocity. The computer, taking inputs from other ambient condition sensors, will establish a new required air velocity and signal an appropriate adjustment in fan speed.



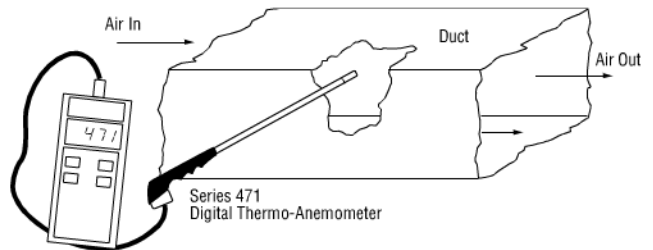
Either of two methods used to measure air velocity.

To measure air velocity, connect a Dwyer® Magnehelic® or Mini-helic® differential pressure gage, or a Dwyer® Durablock® inclined manometer to a Pitot tube in the air stream as shown. The alternative method at right requires only a static tap plus a simple tube in center of duct to pick up total pressure. The differential pressure reading on the gage or manometer is velocity pressure, which may be converted to air velocity by calculation or reference to conversion chart. Where air density is known, the gage manometer can also be calibrated directly in velocity units. If you need an alarm or control function to maintain a preset air velocity limit, install a Photohelic® switch/gage. Dwyer® stainless steel Pitot tubes are made in numerous lengths and configurations to serve in the smallest to the largest duct size.



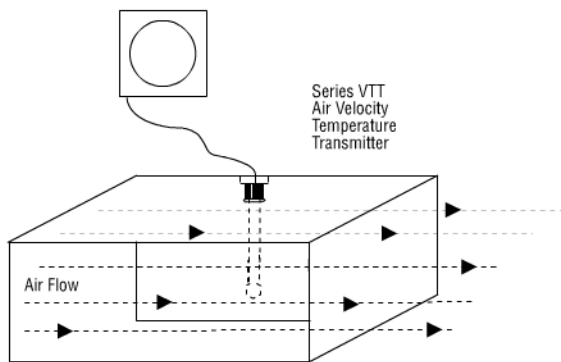
Air velocity transmitter controls drying oven air flow.

The flow of heated air is held to a constant predetermined velocity in this carefully controlled low temperature process drying oven. The constant temperature air supply is modulated by a set of inlet louvers operated by a servo-driven actuator. A Dwyer® Series 641 Air Velocity Transmitter has an optional LED display for local indication of air flow. The LED display provides a quick, visual acknowledgement of proper system performance. The controller compares the Series 641's signal to the setpoint in the controller and continuously signals appropriate louver adjustments to the actuator.



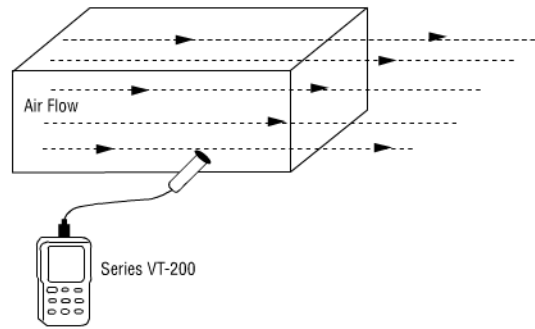
Determine air velocity and temperature levels in ducts or air supply grills.

The Dwyer® Series 471 Digital Thermo-Anemometer is the ideal portable product for determining air velocity and temperature levels in ducts or air supply grills. The 471-1's versatility is due to its four field selectable ranges from 0-500 FPM (0-3 MPS) up to 15,000 FPM (70 MPS). With a push of a button, FPM and Fahrenheit readings are converted to MPS and Celsius. Readings may be stored and retrieved which allows the user greater efficiency with HVAC balancing at various locations in a building. Model 471-2 has an extendable probe and model 471-3 provides a bendable extending probe for hard to reach sampling locations.



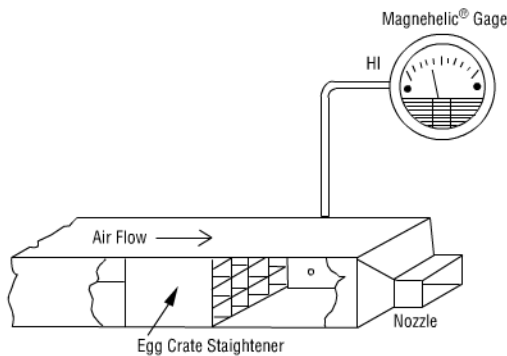
Eliminate the need for Pitot tubes, orifice plates, differential pressure sensors and temperature sensors with a Series VTT.

Installing air velocity measurement systems can be a burdensome process – specifying Pitot tubes, static pressure tips, orifice plates, differential pressure transmitters, etc. Dwyer offers the VTT Air Velocity/Temperature Transmitter to consolidate these components into one convenient instrument. The VTT can be easily installed into the duct or air stream to accurately measure air flow while providing local indication as well as linear analog output for both velocity and temperature. Microprocessor-based technology ensures accurate, repeatable results. The VTT combines these features for simple, reliable airflow measurement without the problems associated with complex, traditional systems.



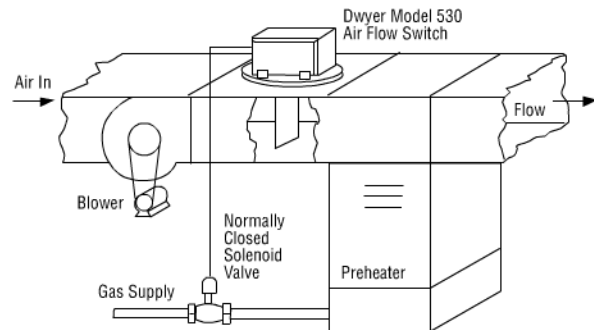
Handheld anemometer enables measuring duct flow measurements.

Handheld anemometers are an excellent, portable tool for performing tests on HVAC system performance; however, large rotating vanes can prevent easy access to ducts. Dwyer introduces the VT-200 Vane Thermo-Anemometer to eliminate this problem. Additionally, simple keypad programming enables the user to view volumetric flow rates in CFM or CMM. Datalogging software is also available to easily record and view data on a PC or laptop.



Measuring velocity or volume of air flow in duct.

A small flow nozzle with an egg crate air straightener located upstream in a large duct provides an accurate, easily constructed air velocity measurement system. Air velocity distribution at the point of discharge across the outlet of nozzle is uniform, and static pressure is zero (atmospheric). Consequently, in the low flow area upstream from the nozzle, static and total pressure at nozzle outlet. As a result, the air velocity and/or volume of flow is easily calculated. The Dwyer Magnehelic® differential pressure gage or manometer can be calibrated to read air velocity or volume directly - assuming standard or constant air density (i.e. temperature, humidity, and pressure). A Photohelic® switch/gage can be used if an alarm or control function is required at a given air velocity or volume.



Air flow switch protects preheater from overheating.

Dangerous overheating would occur in this gas-fueled air preheater if the blower fails or the air flow is obstructed. To protect against this condition, a Dwyer Model 530 air flow switch wired to the gas supply solenoid valve will close the valve if the air flow fails. A normally closed solenoid valve is specified to provide for fail-safe operation of this protective system. Where hazardous ambient conditions exist, a W.E. Anderson® Model V4 Flotect® explosion proof flow switch can also be used. In addition, a Mercoïd® Model M-51 temperature switch can be used to monitor preheater temperature.



Air Velocity Measurement

Introduction

In air conditioning, heating and ventilating work, it is helpful to understand the techniques used to determine air velocity. In this field, *air velocity* (distance traveled per unit of time) is usually expressed in feet per minute (FPM). By multiplying air velocity by the cross section area of a duct, you can determine the air volume flowing past a point in the duct per unit of time. *Volume flow* is usually measured in cubic feet per minute (CFM).

Velocity or volume measurements can often be used with engineering handbook or design information to reveal proper or improper performance of an airflow system. The same principles used to determine velocity are also valuable in working with pneumatic conveying, flue gas flow and process gas systems. However, in these fields the common units of velocity and volume are sometimes different from those used in air conditioning work.

To move air, fans or blowers are usually used. They work by imparting motion and pressure to the air with either a screw propeller or paddle wheel action. When force or pressure from the fan blades causes the air to move, the moving air acquires a force or pressure component in its direction of motion due to its weight and inertia. Because of this, a flag or streamer will stand out in the air stream. This force is called *velocity pressure*. It is measured in inches of water column (w.c.) or water gage (w.g.). In operating duct systems, a second pressure is always present. It is independent of air velocity or movement. Known as *static pressure*, it acts equally in all directions. In air conditioning work, this pressure is also measured in inches w.c.

In pressure or supply systems, static pressure will be positive on the discharge side of the fan. In exhaust systems, a negative static pressure will exist on the inlet side of the fan. When a fan is installed midway between the inlet and discharge of a duct system, it is normal to have a negative static pressure at the fan inlet and positive static pressure at its discharge.

Total pressure is the combination of static and velocity pressures, and is expressed in the same units. It is an important and useful concept to use because it is easy to determine and, although velocity pressure is not easy to measure directly, it can be determined easily by subtracting static pressure from total pressure. This subtraction need not be done mathematically. It can be done automatically with the instrument hook-up.

Sensing Static Pressure

For most industrial and scientific applications, the only air measurements needed are those of static pressure, total pressure and temperature. With these, air velocity and volume can be quickly calculated.

To sense static pressure, six types of devices are commonly used. These are connected with tubing to a pressure indicating instrument. Fig. 1-A shows a simple thru-wall static pressure tap. This is a sharp, burr-free opening through a duct wall provided with a tubing connection of some sort on the outside. The axis of the tap or opening must be perpendicular to the direction of flow. This type of tap or sensor is used where air flow is relatively slow, smooth and without turbulence. If turbulence exists, impingement, aspiration or unequal distribution of moving air at the opening can reduce the accuracy of readings significantly.

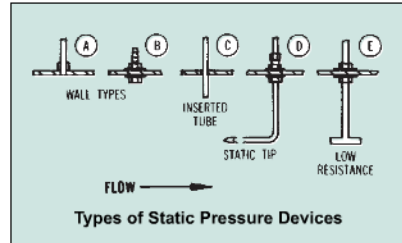


Fig. 1-B shows the Dwyer® No. A-308 Static Pressure Fitting. Designed for simplified installation, it is easy to install, inexpensive, and provides accurate static pressure sensing in smooth air at velocities up to 1500 FPM.

Fig. 1-C shows a simple tube through the wall. Limitations of this type are similar to wall type Fig. 1-A.

Fig. 1-D shows a static pressure tip which is ideal for applications such as sensing the static pressure drop across industrial air filters and refrigerant coils. Here the probability of air turbulence requires that the pressure sensing openings be located away from the duct walls to minimize impingement and aspiration and thus insure accurate readings. For a permanent installation of this type, the Dwyer® No. A-301 or A-302 Static Pressure Tip is used. It senses static pressure through radially-drilled holes near the tip and can be used in air flow velocities up to 12,000 FPM.

Fig. 1-E shows a Dwyer® No. A-305 low resistance Static Pressure Tip. It is designed for use in dust-laden air and for rapid response applications. It is recommended where a very low actuation pressure is required for a pressure switch or indicating gage – or where response time is critical.

Measuring Total Pressure and Velocity Pressure

In sensing static pressure we make every effort to eliminate the effect of air movement. To determine velocity pressure, it is necessary to determine these effects fully and accurately. This is usually done with an impact tube which faces directly into the air stream. This type of sensor is frequently called a “total pressure pick-up” since it receives the effects of both static pressure and velocity pressure.

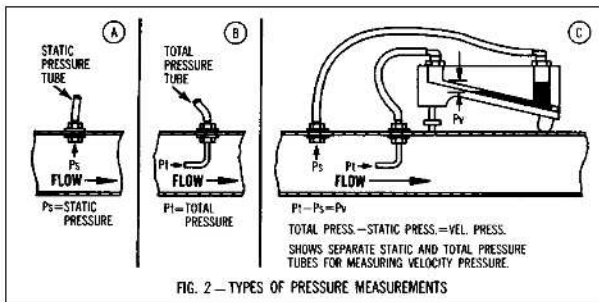


FIG. 2—TYPES OF PRESSURE MEASUREMENTS

In Figure 2, note that separate static connections (A) and total pressure connections (B) can be connected simultaneously across a manometer (C). Since the static pressure is applied to both sides of the manometer, its effect is cancelled out and the manometer indicates only the velocity pressure.

To translate velocity pressure into actual velocity requires either mathematical calculation, reference to charts or curves, or prior calibration of the manometer to directly show velocity. In practice this type of measurement is usually made with a Pitot tube which incorporates both static and total pressure sensors in a single unit.

Essentially, a Pitot tube consists of an impact tube (which receives total pressure input) fastened concentrically inside a second tube of slightly larger diameter which receives static pressure input from radial sensing holes around the tip. The air space between the inner and outer tubes permits transfer of pressure from the sensing holes to the static pressure connection at the opposite end of the Pitot tube and then, through connecting tubing, to the low or negative pressure side of a manometer. When the total pressure tube is connected to the high pressure side of the manometer, velocity pressure is indicated directly. See Figure 3.

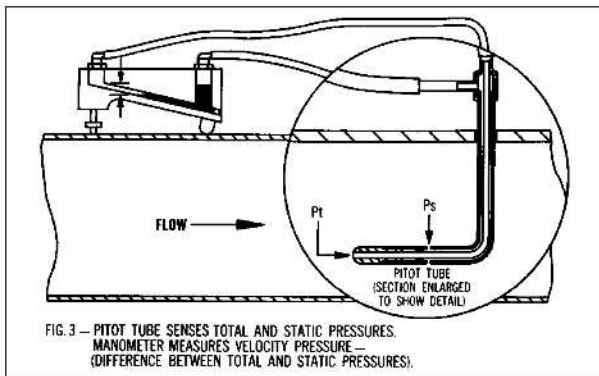


FIG. 3—PITOT TUBE SENSES TOTAL AND STATIC PRESSURES. MANOMETER MEASURES VELOCITY PRESSURE—(DIFFERENCE BETWEEN TOTAL AND STATIC PRESSURES).

Since the Pitot tube is a primary standard device used to calibrate all other air velocity measuring devices, it is important that great care be taken in its design and fabrication. In modern Pitot tubes, proper nose or tip design — along with sufficient distance between nose, static pressure taps and stem — will minimize turbulence and interference. This allows use without correction or calibration factors. All Dwyer® Pitot tubes are built to AMCA and ASHRAE standards and have unity calibration factors to assure accuracy.

To insure accurate velocity pressure readings, the Pitot tube tip must be pointed directly into (parallel with) the air stream. As the Pitot tube tip is parallel with the static pressure outlet tube, the latter can be used as a pointer to align the tip properly. When the Pitot tube is correctly aligned, the pressure indication will be maximum.

Because accurate readings cannot be taken in a turbulent air stream, the Pitot tube should be inserted at least 8-1/2 duct diameters downstream from elbows, bends or other obstructions which cause turbulence. To ensure the most precise measurements, straightening vanes should be located 5 duct diameters upstream from the Pitot tube.

How to Take Traverse Readings

In practical situations, the velocity of the air stream is not uniform across the cross section of a duct. Friction slows the air moving close to the walls, so the velocity is greater in the center of the duct.

To obtain the average total velocity in ducts of 4" diameter or larger, a series of velocity pressure readings must be taken at points of equal area. A formal pattern of sensing points across the duct cross section is recommended. These are known as traverse readings. Figure 4 shows recommended Pitot tube locations for traversing round and rectangular ducts.

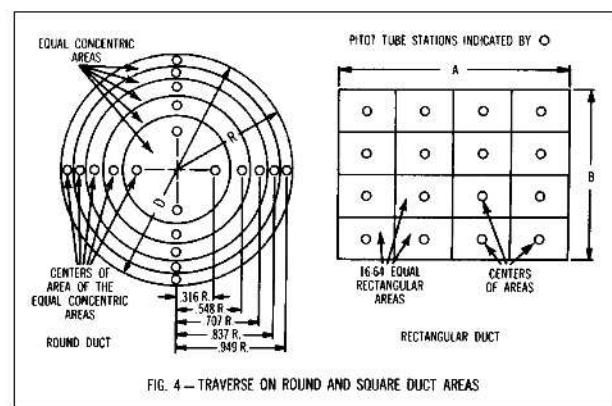


FIG. 4—TRAVERSE ON ROUND AND SQUARE DUCT AREAS

In round ducts, velocity pressure readings should be taken at centers of equal concentric areas. At least 20 readings should be taken along two diameters. In rectangular ducts, a minimum of 16 and a maximum of 64 readings are taken at centers of equal rectangular areas. Actual velocities for each area are calculated from individual velocity pressure readings. This allows the readings and velocities to be inspected for errors or inconsistencies. The velocities are then averaged.

By taking Pitot tube readings with extreme care, air velocity can be determined within an accuracy of $\pm 2\%$. For maximum accuracy, the following precautions should be observed:

1. Duct diameter should be at least 30 times dia. of Pitot tube.
2. Locate the Pitot tube in a duct section providing 8-1/2 or more duct diameters upstream and 1-1/2 or more diameters downstream of Pitot tube free of elbows, size changes or obstructions.
3. Provide an egg-crate type of flow straightener 5 duct diameters upstream of Pitot tube.
4. Make a complete, accurate traverse.

In small ducts or where traverse operations are otherwise impossible, an accuracy of $\pm 5\%$ can frequently be achieved by placing Pitot tube in center of duct. Determine velocity from the reading, then multiply by 0.9 for an approximate average.

Calculating air velocity from velocity pressure

Manometers for use with a Pitot tube are offered in a choice of two scale types. Some are made specifically for air velocity measurement and are calibrated directly in feet per minute. They are correct for standard air conditions: i.e. air density of .075 lbs. per cubic foot which corresponds to dry air at 70°F, barometric pressure of 29.92 inches Hg. To correct the velocity reading for other than standard air conditions, the actual air density must be known. It may be calculated if relative humidity, temperature and barometric pressure are known.

Most manometer scales are calibrated in inches of water. Using readings from such an instrument, the air velocity may be calculated using the basic formula:

$$V = 1096.7 \sqrt{\frac{h_v}{d}} \left\{ \begin{array}{l} -4004.4\sqrt{h_v} \text{ for } .075 \text{ lb/ft}^3 \text{ dry air} \\ @ 70^\circ\text{F, } 29.92 \text{ in. Hg Baro.} \end{array} \right.$$

Where: V = Velocity in *feet per minute*.
 h_v = Velocity pressure in *inches of water*.
 d = Density of air in *pounds per cubic foot*.

To determine dry air density, use the formula:

$$d = 1.325 \frac{P_B}{T}$$

Where: d = Air density in *pounds per cubic foot*.
 P_B = { Barometric (or absolute) static pressure }
 in *inches of mercury*.
 T = Absolute temperature (indicated temperature in °F plus 460°).

With dry air at 29.9 inches mercury, air velocity can be read directly from curves on the following page. For partially or fully saturated air a further correction is required. To save time when converting velocity pressure into air velocity, the Dwyer® Air Velocity Calculator may be used. A simple slide rule, it provides for all the factors needed to calculate air velocity quickly and accurately. It is included as an accessory with each Dwyer® Pitot tube.

To use the Dwyer® Calculator:

1. Set relative humidity on scale provided. On scale opposite known dry bulb temperature, read correction factor.
2. Set temperature under barometric pressure scale. Read density of air over correction factor established in 1 (above).
3. On the other side of calculator, set air density reading just obtained on the scale provided.
4. Under Pitot tube reading (velocity pressure, inches of water) read air velocity, feet per minute.

Determining Volume Flow

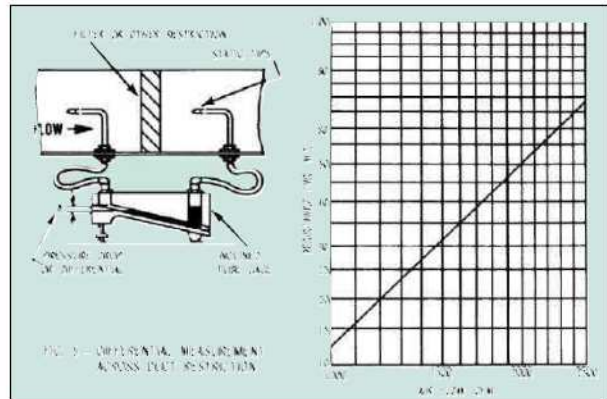
Once the average air velocity is known, the air flow rate in cubic feet per minute is easily computed using the formula:

$$Q = AV$$

Where: Q = Quantity of flow in *cubic feet per minute*.
 A = Cross sectional area of duct in *square feet*.
 V = Average velocity in *feet per minute*.

Determining Air Volume by Calibrated Resistance

Manufacturers of air filters, cooling and condenser coils and similar equipment often publish data from which approximate air flow can be determined. It is characteristic of such equipment to cause a pressure drop which varies proportionately to the square of the flow rate. Figure 5 shows a typical filter and a curve for air flow versus resistance. Since it is plotted on logarithmic paper, it appears as a straight line. On this curve, a clean filter which causes a pressure drop of .50 inches w.c. would indicate a flow of 2,000 c.f.m.



For example, assuming a manufacturer's specification for a filter, coil, etc:

Given Flow Q (ft³/min.) - at differential "h"
 (inches w.c.)

To determine flow at other differentials the formula is:

$$Q_n \text{ (other flows)} = Q \sqrt{\frac{h_n}{h}}$$

Where: Q = Quantity of flow in *cubic feet per minute*
 h = differential in *inches water column*
 h_n = differential (other flow conditions)

Other Devices for Measuring Air Velocity

A wide variety of devices are commercially available for measuring air velocities. These include hot wire anemometers for low air velocities, rotating and swinging vane anemometers and variable area flowmeters.

The Dwyer® No. 460 Air Meter is one of the most popular and economical variable area flowmeter type anemometers. Quick and easy to use, it is a portable instrument calibrated to provide a direct reading of air velocity.

A second scale is provided on the other side of the meter to read static pressure in inches w.c. The 460 Air Meter is widely used to determine air velocity and flow in ducts, and from supply and return grilles and diffusers. Two scale ranges are provided (high and low) with calibrations in both f.p.m. and inches w.c.

To Check Accuracy

Use only devices of certified accuracy. All anemometers and to a lesser extent portable manometers should be checked regularly against a primary standard such as a hook gage or high quality micromanometer. If in doubt return your Dwyer® instrument to the factory for a complete calibration check at no charge.

AIR VELOCITY FLOW CHARTS

