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INDUSTRIAL PROCESS AIR HANDLING & MEASUREMENT

Air Velocity/Volume Measurement

INTRODUCTION

The movement of air is a factor in almost all modern industrial facilities. Industrial air movement is usually categorized as either heating/ventilating/air conditioning (HVAC) or process air.

HVAC air is used for both creature comfort and/or maintaining proper temperature and humidity for the manufacturing process.

Process air is an integral part of the process. Without the specific volume, pressure, velocity, etc. the process will begin to either deteriorate or stop.

Volumes of information can be found on the movement and control of HVAC Air, but very little data is available for determining and understanding process air requirements. The very foundation for understanding industrial process air systems is the ability to accurately measure air flow and analyze the data. The following information specifically relates to process air but is useful for HVAC systems as well.

BASIC TERMS:

Air Velocity is usually measured in feet per minute (FPM) or meters per second (MPS). It is a statement of distance traveled in a unit of time.

Air Volume (Quantity, Flow) is usually measured in cubic feet per minute (CFM) or cubic meters per hour (M3/H).

Fans (Blowers, Ventilators) are used to move air. Two common types are: Propeller (Axial) and Paddle Wheel (Radial). Both types give direction or motion and pressure to the air. The moving air has a pressure component in the direction of motion due to weight and momentum.

This force component is called Velocity Pressure (Pv) and is measured in inches or millimeters of water column (W.C.) or water gauge (W.G.).

Industrial duct systems have a second pressure present, which is independent of velocity or movement. This second force is known as Static Pressure. It exerts an equal force in all directions and is also measured in inches or millimeters water column (W.C.) or water gauge (W.C.) Static pressure is usually negative on the system fan inlet and positive on the outlet. The exception to this is when fans are connected in series or tandem.

The combination of static and velocity pressure is Total Pressure and is measured in the same units. Total Pressure is very useful and east to measure. Velocity Pressure is difficult to measure but can be determined easily by subtracting Static Pressure from Total Pressure. Individual measures can be made and then subtracted or accomplished with a gauge and Pitot tube hook-up.

Cross-Sectional Area is the actual inside area of a duct or pipe. This area is measured in square feet or square meters.

CALCULATING AIR VOLUME:

The quantity or volume (Q) of air moving through a duct is easy to determine once you have the average velocity (V) and cross-sectional area (A) of the duct. The formula is Q=AV. This will give you quantity of air at standard conditions. Standard air is 0.075 pound per cubic foot, dry air at 70 F and 29.92 inches of mercury (one atmosphere) barometric pressure (sea level). Always be aware that temperature, humidity, elevation, suspended material, etc. may cause volume/quantity to vary. Correction factors may be used if your conditions vary greatly from standard conditions and/or extreme accuracy is required.

STATIC PRESSURE MEASURE

Static Pressure can be measured with several simple devices. Either rigid or flexible tubing connects the device to a pressure gauge.

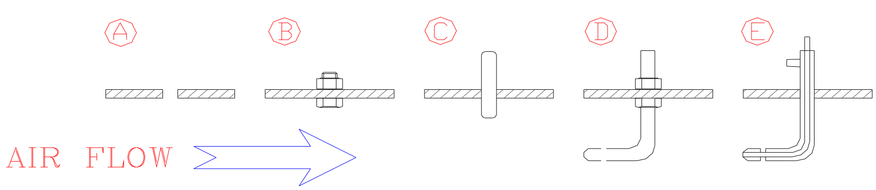


FIGURE 1

FIGURE 1-A shows a simple drilled hole in the duct wall. The size of this hole is usually 0.125 (1/8) inch or 3mm to 4mm diameter. The flexible tube is held tightly over this hole while the gauge reading is recorded. Fast and simple but it requires the tube to be held in place.

FIGURES 1-B and 1-C provide a more permanent mounting of tubing and are accurate at velocities up to 3,000 FPM.

FIGURE 1-D illustrates a static tip fitting, which is excellent for permanent mounting and is accurate at velocities up to 10,000 FPM. This device is ideal for measuring differential pressure (DROP) across filter, coils and other industrial apparatus. The pressure is sensed through radial holes near the tip.

Under actual industrial conditions, duct size, configuration, and flow turbulence may necessitate the use of a pitot tube (FIGURE 1-E).

STATIC PRESSURE MEASURE:

This pitot tube is connected to a gauge using only a single tube on the pitot static pick-up and on the positive (High) or negative (Low) connection of the gauge. The 900 static sensing holes will allow more accurate readings under fluctuating conditions.

TOTAL PRESSURE AND VELOCITY PRESSURE MEASURE:

Velocity Pressure must be determined by using a pressure sensor tube facing into the air flow. The tube receives the full impact of the airstream and measures total pressure (Pv + Ps - Pt).

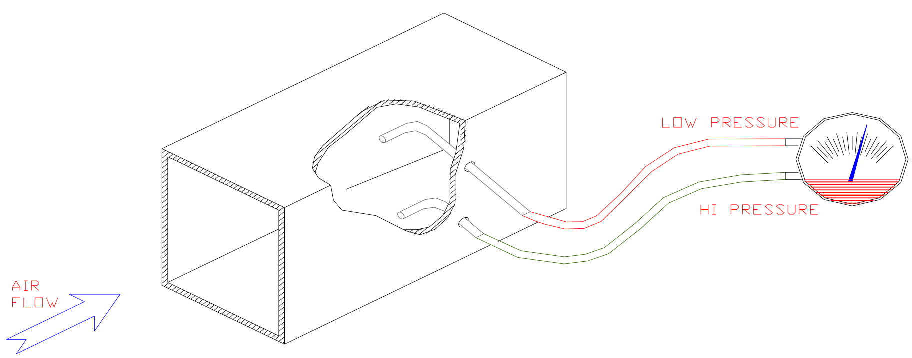


FIGURE 2

FIGURE 2 illustrates a separate sensor for static pressure (Ps) and total pressure (Pv + Ps). Static pressure is applied to both sides of the gauge, therefore, canceling the effect of static pressure and giving a gauge reading of only the velocity pressure (Pv).

The accepted method of taking a velocity pressure reading is with the use of a pitot tube. This device is actually a tube within a tube giving both static and total pressure sensors. Many sizes are available with common diameters being 1/8 inch (3mm) and 3/8 inch (9.5mm). Insertion lengths are available from 6 inch (152mm) to 60 inch 1524mm).

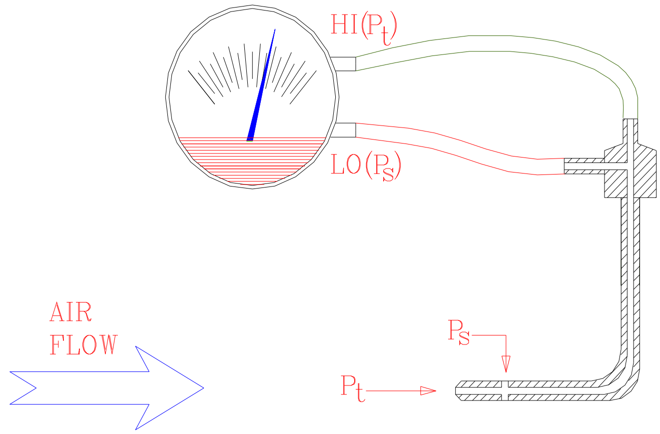


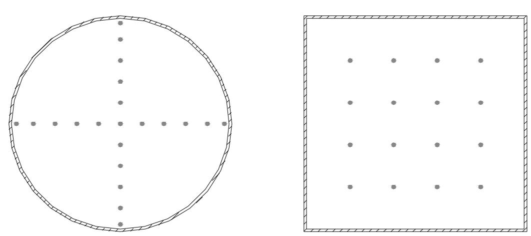
FIGURE 3

FIGURE 3 shows proper set-up for velocity readings. It is important that the pitot tube tip be aligned to be parallel with air flow and face directly into the airstream. Since turbulence distorts readings, measurements should be made 6 to 8 duct diameters downstream from elbows, lateral taps or other fittings.

TRAVERSE READINGS:

Since duct wall friction slows airflow, velocity near duct walls is less than the duct center. The traverse readings establish an average velocity within the duct cross-section. Technically, a pattern of points of equal area should be measured across the duct. In "laboratory" conditions this is fine but actual field readings are usually in a compromising position.

It is recommended that a reading be taken at least each inch along two diameters on a round duct (See FIGURE 4) and at least four positions on two adjacent sides on a rectangular duct (See figure 4).



• INDICATES PITOT READING POINT

FIGURE 4

Calculate velocity by averaging the traverses to give an overall average velocity. When exact (+/-2% to 5%) velocity is not required, several traverses may be made while watching the gauge. A mental average can then be determined. An alternative method to determine a working average velocity is to place the pitot tube in the center of the duct and make note of the reading. This reading Multiplied by 0.90 will give an approximate average. These methods are very useful in actual industrial applications where material is moving through the duct and/or velocity fluctuates with the process. Both situations require rapid measurements. Back blow both connections on pitot tube to ensure openings are free from material blockage!

USING VELOCITY PRESSURE TO CALCULATE AIR VELOCITY:

It is recommended that a manometer with a dual scale be used with pitot tube measurements. This gauge measures both velocity pressure (Pv) and velocity (FPM) for standard air conditions (0.075 lbs. Per cubic foot, 700F @ 29.92 inches Hs).

If you choose to use Pv readings, most pitot tubes are supplied with a slide rule calculator to convert to velocity in FPM.

Once the velocity is determined, simply multiply velocity times cross-sectional area to yield air volume. Be sure to "consider" altitude, temperature, etc. on final calculation.

An alternate method of determining air volume can be used on most air systems when the system fan data table or curve is available. This method can be used to check pitot tube reading or in lieu of pitot reading where impossible. The following date is required:

1. Fan inlet static pressure
2. Fan outlet static pressure
3. Fan speed (RPM)
4. Brake Horsepower (BHP)

Add inlet and outlet static (dropping positive or negative) to give total static or "Head" on Fan; i.e. -6" on inlet and +2.5" on outlet equals 8.5 inches static pressure. Measure speed with a tachometer or calculate knowing drive ratio and motor nameplate speed. Determine Brake Horsepower (BHP) or kilowatt (KW) by measuring actual amps and dividing by nameplate amps and multiplying times HP or KW.

Once these factors are recorded, the only missing factor is volume. Refer to Fan Performance Table/Curve to plot approximate volume. This method will usually get you within 10% of the actual volume.

SUMMARY:

Other reliable devices for measuring air velocity include hot wire anemometers; rotating vane anemometers, permanent station pitot, etc. While accurate, these are usually not practical for industrial process air systems. A general profile of system performance is usually more important than a single series of very accurate readings.

It is very helpful to take a complete set of readings once a system is started. These readings will serve as a "Base Reference" for any future changes and/or adjustments. Take static pressure readings at various points throughout the system to detect any dramatic changes indicating blockage or other malfunction. Operating amps on fans can also be a useful measure since amps and air volume are in direct proportion, i.e. A decrease or increase in amps will indicate a decrease or increase in air volume. Remember it takes HP/KW to move air!

Readings must be neatly and accurately recorded in order to be useful to others. Be sure to note date, shift, time, process conditions, raw materials, temperature, elevation and other factors of interest.

The actual measurements are simple to obtain. The real talent is to use this data to determine the basic operating profile of the system. It is necessary to understand fan laws as well as the practice of air measurement. Most fan manufacturers have very good catalog data and technical bulletins available to industrial users.

Contact *Ibis* for more information.

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