UPG
Technical Services

APPLICATION ENGINEERING
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TOPIC: Understanding, Measuring And Using Duct Pressures

SCOPE & PURPOSE:

- This bulletin briefly explains pressures in ducts with an emphasis on the measurement and application of static and velocity pressures to the operation of heating and cooling equipment and the associated duct system. The correct measurement and understanding of pressures in ducts, blowers, building structures and across airside components is foundational to the proper design, installation and service of heating and cooling systems.

CONTENT:

- Introduction

The blower creates pressure in ductwork which causes the air to move from the source of the pressure (the blower) which is at the highest pressure, toward the outlet of the duct which is at the lowest pressure (the supply registers in the rooms). All fluids[1] flow from higher pressure to lower pressure.

As the air moves through the ducts the pressure inside the duct gradually decreases until it reaches the same pressure as the conditioned area (rooms) as it leaves the supply registers.

The duct walls and fittings have resistance to the flow of air as the air rubs or contacts against the sheet metal walls. Additionally, any apparatus installed in the duct such as filters, heating or cooling coils and other devices add more resistance to the

[1] Air is a fluid as is any gas, vapor or liquid with the ability to flow. Fluid flow can be measured in a variety of ways and may be stated to flow in lbs per minute, cubic feet per minute, gallons per minute, etc...

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flow of air. Resistance to the flow of air causes the pressure to drop as the air flows through the item having resistance.[2]

Therefore, it is possible to measure a pressure difference (pressure differential) from one side of a filter, coil or other device to the other side by utilizing a pressure sensitive instrument. Pressure readings can be used to analyze the operation, efficiency and deficiencies of the blower, duct system, duct fittings and installed apparatuses. The pressure differential or pressure difference across a filter increases as the filter loads with dust, dirt and debris. Therefore, it is possible to compare the "clean" pressure drop to the "dirty" pressure drop to determine when the filter is in need of replacement.

Since each item in the duct such as a filter, cooling coil, heating coil, duct fittings and other items creates resistance to flow and drops pressure across the component it is necessary to ensure that

1. The blower has enough capacity to overcome the resistance of the duct system and installed components.
2. That the duct system resistance is not too great for the blower capacity.[3]
3. Or, the combination of 1 & 2 above are acceptable.

Most residential heating-cooling blowers are designed to be capable of producing .5 inches of static pressure. Many light commercial rooftop units are capable of producing 1 to 1.5 inches of static pressure. Refer to the manufacturer's blower table for the specific unit being utilized.

Pressures In Ducts

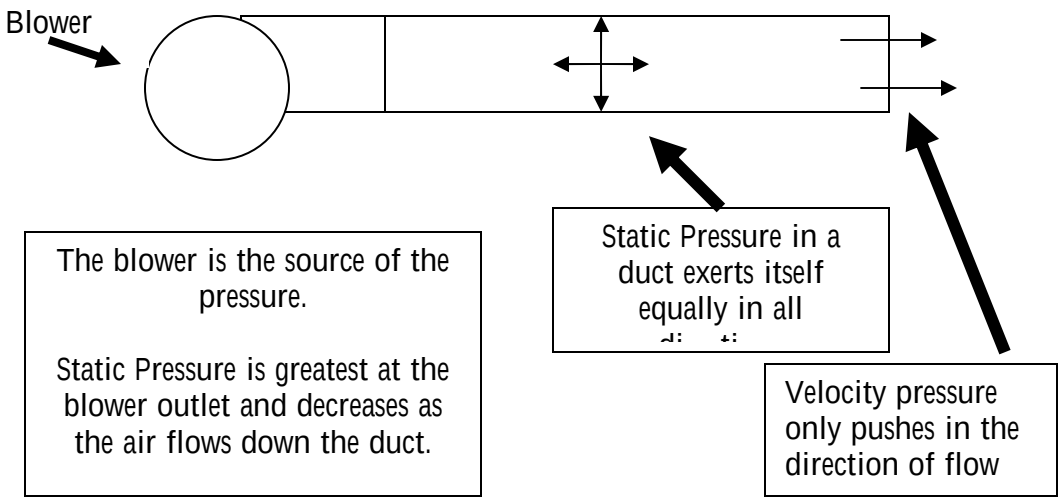
There are actually two pressures in ducts, static pressure and velocity pressure. Added together they equal the total pressure. The following diagrams illustrate pressures in ducts.

Pressure

Atmospheric pressure is caused by the weight of air. Air higher in the atmosphere pushes down on the air below it causing it to compress. Therefore, the air closer to the earths surface is more dense (compressed) than air at higher altitudes. A one-square inch column of air extending from the oceans edge to an altitude of 60-miles will weigh 14.7 pounds. Thus, we can state that air at sea level exerts a pressure of 14.7 psia. "Pounds per Square Inch Absolute" or "Atmospheric"

[2] The resistance to flow in duct systems is usually referred to by the pressure drop that occurs due to the resistance. Pressure drop is measured and stated in inches or fractions of an inch of water column pressure as measured using one of a variety of test instruments used for that purpose.

[3] Poor or low airflow due to improperly sized ducts is perhaps the most common cause of heating and cooling problems. Duct systems must be designed using proven methods of calculating airflow and resistance. Good duct system design cannot be accomplished without first having completed a heating and/or cooling load calculation.



Static pressure pushes equally in all directions in a duct. Static pressure pushes on the duct walls thus slightly expanding the duct as if the duct were a sheet metal balloon. Static pressure also pushes down the duct in the direction of the flow of air.

Velocity pressure is a second pressure in the duct which when added to the static pressure equals the total pressure. Velocity pressure pushes in the direction of airflow only. Since static pressure also pushes in the direction of airflow as does the velocity pressure, any pressure measurement taken facing the flow of the air will be a measurement of the total air pressure.

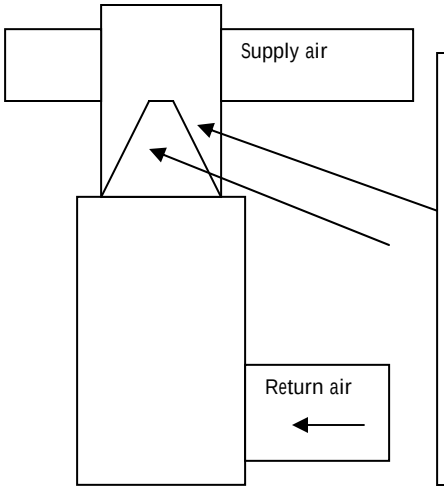
Static Pressure
+ Velocity Pressure
———————
Total Pressure

Example;
The atmospheric pressure of 14.7 psia (at sea level) which pushes on us is static pressure. By measuring static pressure in a duct we can determine duct resistance and pressure drops.

A blowing wind is an example of velocity pressure. Velocity pressure causes movement directly. By measuring velocity pressure in a duct we can determine flow in cubic feet per minute.

As stated earlier, pressure drops across any resistance in the air system. The manufacturer know the resistance of the components installed in the furnace cabinet such as the heat exchanger, air conditioning cooling coil or even a clean factory supplied and installed filter.

Therefore, the manufacturer provides a chart that relates pressure drop across a factory installed component such as an evaporator coil to the air volume passing through that component.



1. Drill 3/16- inch holes the two locations illustrated. One hole on each side of the coil.
2. With the blower operating, measure the pressure drop across the evaporator coil.
3. Using the manufacturers chart for the particular combination of furnace/air handler and coil, read the airflow in CFM for that particular coil pressure drop.

Instrumentation & Measurements

The ideal instrument for measuring static, velocity and total pressures is a digital manometer which will also serve well when reading and adjusting gas pressure regulators on burners. However, an inclined manometer filled with colored oil works well. The following illustrations show the use of an inclined manometer.[4]

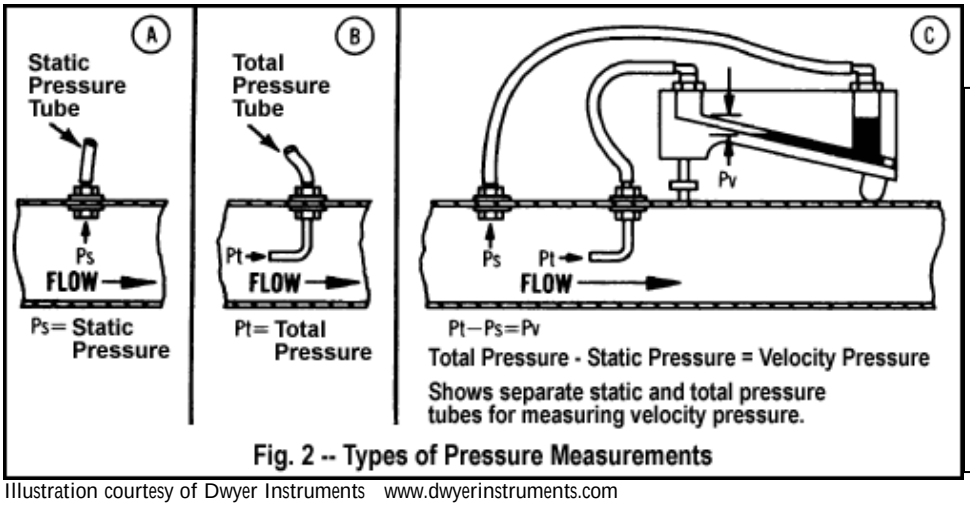


Fig. 2 -- Types of Pressure Measurements

Illustration courtesy of Dwyer Instruments www.dwyerinstruments.com

Pressure differential may be made by taking two static pressure measurements one across each side of the evaporator coil, and subtracting or by using the method in fig. 5 below.

[4] An inclined manometer is one of a number of instruments capable of measuring and analyzing duct systems pressures. Dwyer Instruments manufacturers the Magnehelic gauge and several firms make battery operated digital manometers. All operate on the same principle of measuring pressure differentials in inches of water or fractions of an inch of water.

"A" in the illustration above shows the pressure tube inserted in the duct perpendicular to the flow. This allows for the measurement of the static pressure.

"B" in the illustration above shows the pressure tube inserted in the duct facing the airflow. This method allows the pressure tube to pick up both the static and velocity pressures which are additive thus giving us the total pressure. (Static pressures equally in all directions including in the direction of flow. Velocity pressure pushed in the direction of flow)

"C" above shows the total pressure tube and the static pressure tube connected on opposite sides of an inclined manometer resulting in the manometer reading the difference. Subtracting the static pressure from the total pressure yields the velocity pressure.

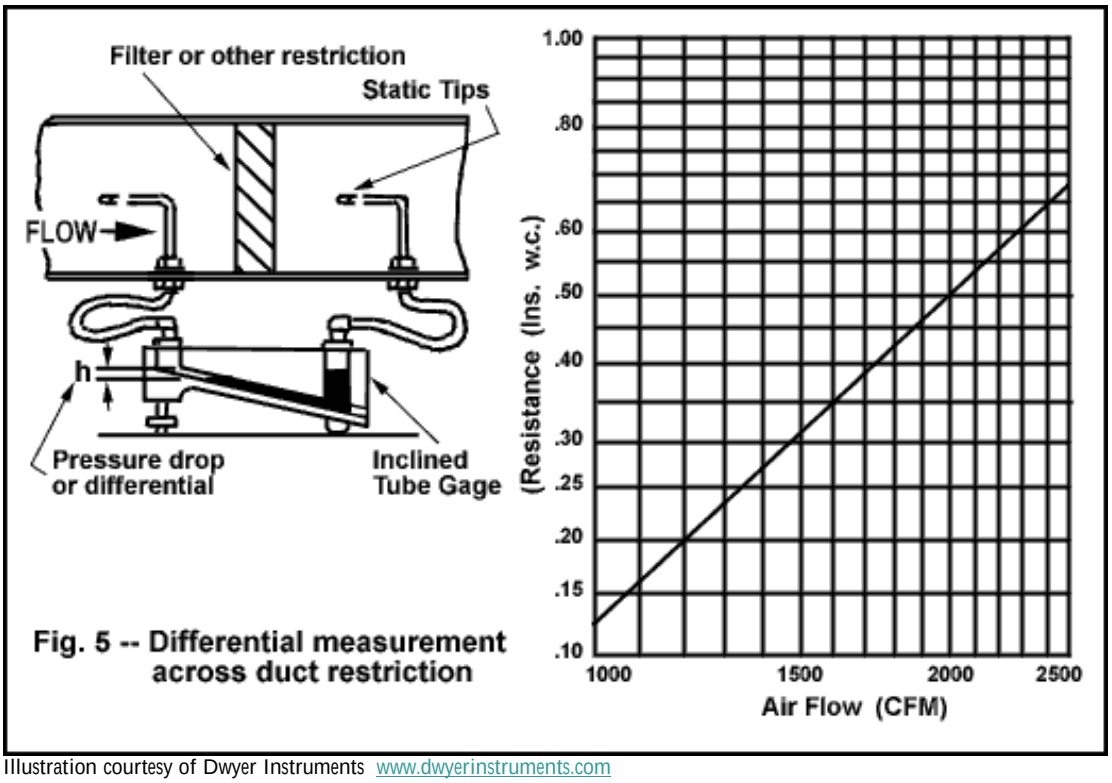


Fig. 5 -- Differential measurement across duct restriction

Illustration courtesy of Dwyer Instruments www.dwyerinstruments.com

Figure 5 shows an inclined manometer measuring the pressure difference across a resistance in the duct.[5] This could be an evaporator coil. Using the manufacturer's table and the measured difference the airflow in CFM can be determined. For example, assume the pressure differential across a coil is measured at .3 inches. Following the graph in Fig 5 it can be seen that the .3 inches intersects with the slanted line at the vertical line representing slightly less than 1500 CFM. This is a common method used by manufacturers to allow field

[5] Inclined manometers must be perfectly level to ensure accuracy. Most inclined manometers have a built in level and magnets for attachment to the duct for ease of use.

measurements of actual airflow on equipment. Each manufacturer produces an airflow to pressure chart or graph for each of their products. It is essential that the correct graph be used and that careful pressure drop measurements are made.[6]

SUMMARY/CONCLUSION:

- Air moves thru the duct system because the blower creates a pressure differential which causes the air to move from areas of higher pressure to lower.
- Measuring air pressure in ducts as well as pressure differentials across components can be used to determine restrictions to airflow, duct system problems and air quantities in CFM. (Cubic Feet Per Minute)
- Total pressure is the sum of the static pressure and the velocity pressure.

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KEY WORDS (For searches)

- Air pressures
- Pressure
- Pressure differential
- Duct pressure
- Static pressure
- Velocity pressure
- Total pressure
- Inclined manometer
- Magnehelic gauge
- Air flow
- Pitot tube
- Inches of water column

[6] For additional information of duct pressures, measurements and airflow, consult any one of the following heating and cooling textbooks. "Refrigeration and Air Conditioning" by Jeffus, published by Prentice Hall. "Refrigeration & Air Conditioning Technology" by Whitman and Johnson, published by Delmar.
An excellent book on airflow is the little book "Airflow In Ducts" by Leo A. Meyer, www.lamabooks.com