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A MATCH MADE IN HVACR HEAVEN

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COMMON Air Measurement MISAPPLICATIONS

Avoid these eight common misapplications when using air measurement tools to ensure indoor air quality.

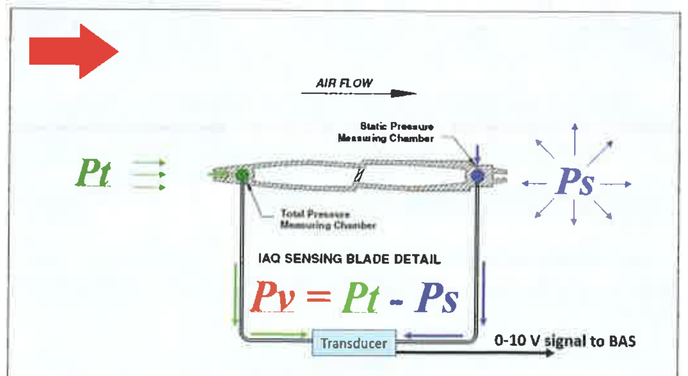
BY GLENN ESSER

Images courtesy of Ruskin.

Introducing outside air can help keep a building and its occupants healthy. The introduction of outside air reduces the rate of microbial growth, which reduces the spread of viruses like cold, flu and other airborne diseases. This is particularly important in schools, college dorms, airports and any space with lots of people. New buildings in particular can benefit from outside air to counter higher volatile organic compounds (VOCs) originating from sources such as new carpet, paint, cleaning agents and cooking odors.

Methods of air measurement

Accurately measuring outside airflow is critical to the efficient operation of building systems and to ensure good indoor air quality. Two basic technologies used most often for airflow measurement are velocity pressure, and electronic air measurement using thermal dispersion sensors.



Velocity pressure explained through a cross-section of a sensing blade. The velocity pressure equals the total pressure minus the static pressure. This pressure is converted to an electronic signal by a transducer.

Velocity pressure is the difference between total pressures on the leading edge of the airflow sensing blade minus static pressure exerted in all directions inside a duct. A low-pressure transducer is connected between two pressure pick-up points in the system and the resulting velocity pressure can be easily converted into an electrical signal. Higher velocities create greater velocity pressure that can be easily converted into an airflow measurement.

Lower velocities create little velocity pressure and are more difficult to measure using inexpensive velocity pressure transducers. Therefore, very accurate low-pressure transducers with internal signal processors or electronic air-measurement devices using a heated and passive thermistor are often better suited for measuring lower velocity airflows. With a thermal dispersion air measurement device (TDAMD), the amount of heat dissipated from the heated thermistor is a function of both the temperature and speed at which the air is passing over the sensors. The math for this is a little more complex but has been well-established in the industry as a reliable means of measuring airflow. TDAMDs can measure airflow down to nearly zero, where the lower limit of a velocity pressure device is 150-300 ft/minute, depending on the signal processor or transducer, and the installation.

Common measurement misapplications

While accurate airflow measurement is critical to keeping building systems running efficiently, too often there are misapplications that can lead to higher energy costs, increased maintenance, and in many cases, unhealthy buildings.

Common misapplication 1: Airflow going two directions through the plane of the air measurement station.

This can occur when putting the air measurement station close to a 90-degree elbow or where two airflows merge together. Depending where the air measurement station is placed and what air measurement technology is applied, unstable readings are generally an indication of air going in and coming out at the same time. Velocity pressure only generates a positive pressure when airflow is passing in the intended direction.

›› Air measurement stations can be installed as part of the ductwork so the station and its placement can be pre-determined.

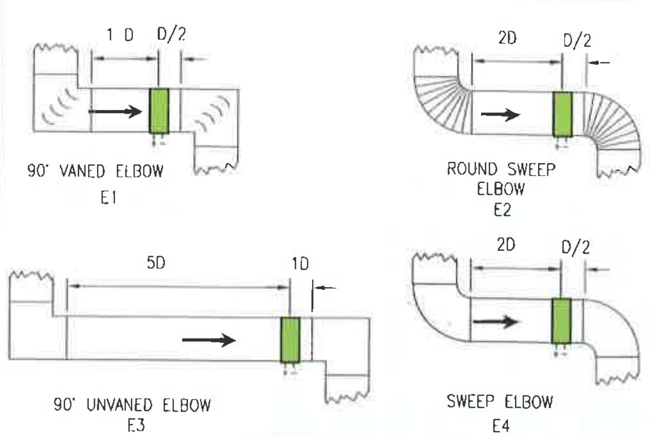
Electronic air measurement is direction insensitive. By applying electronic filtering either device can be made to appear more stable. However, unstable airflow measurements should be closely examined for the root cause. Then, when possible, relocate the equipment to a point in the duct or resize the opening to get a relatively uniform airflow through the plane of the measurement station.

Common misapplication 2: Ignoring the expected velocity through an outside air opening. With electronic air measurement probes installed in an outside air hood it is not uncommon to show a decent amount of airflow from air movement in the area where the sensors are installed, even when the outside damper is closed. Therefore, it is important to specify the size of the opening to generate an acceptable velocity for the airflow that is expected to be measured, when not operating in economizer mode.

An engineer might select an electronic air measurement device using the following thought process: "I have 50 ft/minute velocity from the outside air opening when operating at 10% outside air. Therefore, I should have an air measurement device that will read down to 0 ft/minute, so I will just put electronic air measurement probes in this opening." The engineer did not account for wind speed, or air that might be blowing out through that opening.

Electronic sensors do not care whether air is coming in or going out, so airflow will be read in either direction. At that very low velocity, it is important to make sure things are laid out correctly and that the air is moving in the right direction through the plane of the air measurement device. Higher operating velocities are less susceptible to prevailing breezes and wind gusts. A velocity equal to the return air velocity through the mixing box is the most desirable because it promotes complete mixing of the outside air and return air. This can be accomplished by using a smaller portion of the total area under the outside air hood.

A thermal dispersion air measurement tool makes it possible to do a true traverse or real-time sampling or indication of the airflow in the duct in both a velocity profile and a temperature profile.



Air measurement can be more accurate and less problematic when air measurement considerations are accounted for in the mechanical specification and building design. The acceptable placement of an air measurement device is shown in green.

Common misapplication 3: Ignoring air measurement considerations during the building design.

Air measurement can be more accurate and less problematic when air measurement considerations are accounted for in the mechanical specification and building design. Good design principles place air measurement stations in a straight run of duct, or lay out the right opening size and allow for the necessary upstream-downstream spacing for air measurements to work well. Air measurement stations can be installed as part of the ductwork so the station and its placement can be pre-determined.

Common misapplication 4: Sizing an air measurement station the same size as the outside air opening.

Outside air openings are typically sized not to exceed a maximum velocity when operating with 100% outside air. If the normal amount of air to be measured is only some smaller percentage, then consider subdividing that opening so that the measured airflow is at a greater velocity.

Using a minimum-maximum air measurement station, it is possible to size the minimum portion of the outside air opening for the required minimum outside air at a velocity that will be easy to measure at this location in the system. The balance of the opening is given over to an economizer damper that can be modulated when operating in conditions other than minimum airflow requirement.

Common misapplication 5: Using short transitions, Ts and elbows that introduce turbulence in the airflow.

Simple items like turning vanes in 90-degree elbows and high-efficiency takeoffs in place of square Ts reduce turbulence and pressure drop in the system. These items reduce the overall energy required to move air down the duct, thereby saving operational costs and making it easier to get accurate air measurements. Anything that helps smooth the airflow also reduces energy consumption while increasing the locations where accurate air measurement can be made in the system. Removing pressure drop in a system makes it possible to use smaller fans or operate at lower rpm to move the same amount of air.

Common misapplication 6: Selecting technology that is not suitable for the application.

As stated earlier, two basic technologies are used for air measurement: velocity pressure and electronic airflow measurement. Velocity pressure relies on the speed of the air passing across velocity sensors to generate the pressure, which is very repeatable. But at velocities less than 300 ft/minute, this pressure range is often in the thousandths of an inch of water column, instead of one hundredths of an inch.

Most velocity pressure devices are designed to work at 0.01 in. of water column all the way up to an inch of water column or higher. When operating at less than 300 ft/minute, velocity pressure can still be used, but devices that can accurately read that small pressure tend to be expensive. The cost of the transducer, or signal processor, to read that very low pressure often goes up tenfold.

There are some very good devices that can work down to 200 ft/minute or lower using velocity pressure but the signal processors may cost significant dollars. When operating in these very small units, even a tiny difference in air temperature can make a large difference on the velocity calculation. Temperatures must be monitored so that air density caused by a change in air temperature can be considered.

Conversely, electronic air measurement excels in this lower range. It is important to know when to use electronic devices that do not rely on velocity pressure for measurements in those lower ranges. For example, applications with lower velocity ductwork are better suited for an electronic air measurement solution.

Common misapplication 7: Choosing an electronic sensor with too few sensors.

The concept with electronic air measurement is that the addition of more sensors allows an HVACR pro to measure airflow more accurately even in a less-desirable installation. If the air is moving through the duct at a uniform speed, one or two sensors in the duct might be representative of the airflow and can provide a very good indication of the airflow. However, considering a typical installation with limited space for transitions, turns, elbows and takeoffs, it is better to use more sensors. For example, when all the air is being thrown to one side of the duct, measuring the velocity profile using more points will produce a better reading.

Some electronic air measurement devices offer a maximum of 16 points for measurement, while some have the capability for up to 128 points of measurement, making it possible to do a true traverse or real-time sampling for an accurate indication of the airflow in the duct in both a velocity profile and a temperature profile. This is analogous to integrating the area under the curve in place of estimating the area with fewer points. In large openings, fewer sensors are not as accurate. But adding additional sensors make it possible to work with a greater range of less than ideal situations.

Common misapplication 8: Assuming 0% tolerance in testing and balancing.

When specifying engineers look at the specification for an air measurement station, they will often assume its calibrated tolerance of repeatability (for example, +/- 2%) is the installed accuracy. But, achieving that accuracy is dependent on where the equipment is installed in the system.

It is also assumed the test and balance contractor is using equipment with 0% uncertainty in their measurements. An onsite commissioning agent may spend many unnecessary hours trying to set the system tolerance to some small percentage. It is important to determine the accuracy of the testing and balancing device. For example, how far from an elbow must you be to get a perfect reading? Often the inaccuracy of the testing and balancing equipment plus the uncertainty in the air measurement are not considered.

When a commissioning agent is trying to calibrate the building, he or she may inadvertently cause the building owner to spend additional money. For example, the commissioning agent may assume, "That is not within 5% so you have to do something." A lot of time is then spent in the field calibrating these devices to try and get them to read within a smaller amount of uncertainty.

Often, that level of accuracy is not possible, unless it was laid out correctly and installed in ideal installations. An analogy is that you can have a high-performance sports car designed to go from zero to 60 in three seconds, but not on gravel, or in the rain or snow. To expect the same level of performance, independent of the operating environment, is often unreasonable and unobtainable.

Having the air measurement station sized correctly and installed properly is necessary to get the accuracy within a reasonable tolerance. For example, in return and exhaust fan tracking, large air measurements have large cfm of uncertainty that are often greater than the small difference trying to be maintained. Fan tracking can work in a very porous space where the amount of air coming in and the amount of air taken out cannot be easily measured any other way, for example in a large warehouse or store with open doors. But if the wind blowing on the building pressurizes the space or adds air into the space, then that skews the calculations.

The author has been on sites with large air measurement stations installed in very poor locations. In a non-porous space, for example, they were trying to use the measurement of supply air and return air and take the difference between them to determine what their outside air volume should be, and were then very disappointed that the doors on the building were sometimes blowing open and other times were sucked shut. Air measurements varied from one day to the next and space pressure was out of control. It is difficult, if not impossible, to get accurate repeatability if the system is not designed or laid out correctly.

Conclusion

Air measurement is not difficult to do properly. The air measurement product selected must be sized for an expected range of operating velocities. Higher velocities are often easier to measure and can be more forgiving. Lower velocity applications must be carefully placed with close attention to possible sources of turbulence.

Glenn Esser is a controls engineer at Ruskin, where he helps with engineering and product development for air measurement tools and other HVACR products. Esser has an electrical engineering degree from the University of Missouri and participates on several committees for AMCA.