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ENGINEERING

SYSTEM SOLUTIONS

In this issue, we make a case for why direct outdoor air measurement can be a valuable asset in meeting the minimum ventilation rates prescribed in ASHRAE Standard 62.1-1999 without adding unnecessarily to an owner's operating costs.

The second article introduces our patent-pending DesignFlow™ Precision Outdoor Air Measurement System – the first factory-installed outdoor air measurement system designed specifically for rooftop VAV systems. In rigorous, repetitive testing witnessed by Intertek Testing Services, Inc., the DesignFlow system has demonstrated the ability to consistently measure outdoor air intake volume at >95% of the design set point – substantially higher accuracy than the 90% industry goal.

You can find this and other issues of Engineering System Solutions on our website at www.mcquay.com. Also, check out our "What's New" page for information and literature on DesignFlow, McQuay Applied Rooftop Systems and other McQuay products.

McQuay provides semi-custom system solutions for commercial HVAC applications. This newsletter is written specifically for the HVAC engineering community. We welcome your comments, feedback, and article suggestions.

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Director of Applications
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Outdoor Air Volume Measurement – Look For A Direct Approach

Whether you know the process by name or not, you are probably familiar with the Ventilation Rate Procedure in ASHRAE Standard 62.1-1999. This process allows the minimum ventilation rate for a building project to be calculated based on cfm of outdoor air per person (i.e. 20 cfm/person for offices). Standard 62.1-1999 has a second procedure called the Indoor Air Quality (IAQ) Procedure. This procedure is more involved and requires identifying and controlling contaminants in the occupied space.

The Ventilation Rate Procedure makes the IAQ process relatively straightforward for most projects and represents the minimum that a consulting engineer should provide. Once the required outdoor air rate is known, the plans and specifications for the construction project will usually indicate that the minimum outdoor air rate shall be "met or exceeded" in order to maintain an acceptable ventilation rate.

Herein lies the difficulty. Not meeting the minimum ventilation rate means that IAQ will suffer. Exceeding it can unnecessarily raise the owner's operating costs unless the cooling load is being met by introducing outside air (airside economizer). As a result, it is not enough for the engineer to design a project so that "enough" outside air is delivered. The engineer needs to find a way to deliver the "correct amount" of outside air – always meeting minimum ventilation requirements for good IAQ without adding to the owner's operating costs with excess ventilation.

The Traditional Approach

Most specifications describe the minimum outdoor rate as a percentage of the design flow rate (minimum outdoor air rate is 20%), or as a specific air volume (minimum outdoor air volume is 4,000 cfm). This is often interpreted as *set the outdoor air dampers to a minimum 20%*, which can lead to less than satisfactory results.

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Figure 1. Characteristic Curves of Installed Parallel Blade Dampers

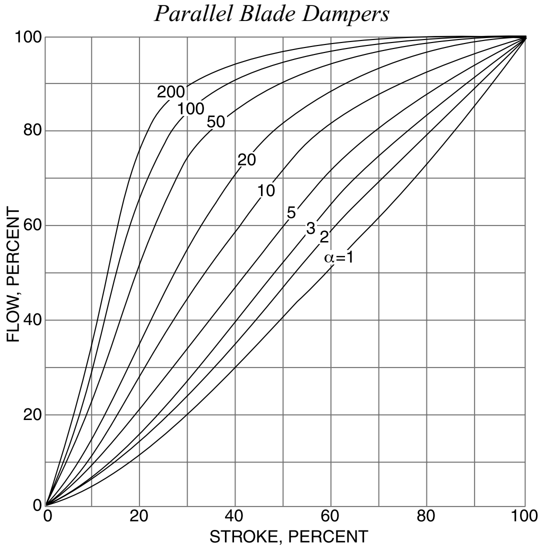
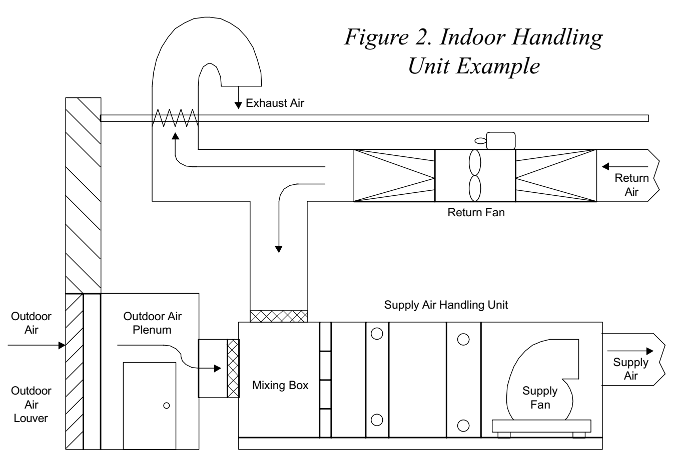


Figure 1 shows percent airflow vs. percent damper open. At 20% open, the airflow can vary from 12% to 75%, depending on the damper selection.

Indoor Air Handling Systems

With indoor air handling systems, the dampers, duct design and layout can be controlled so that reasonable performance is achieved. Figure 2 shows a typical indoor air handling unit installation. To avoid rain entrainment, the velocity through the louver must be lowered to between 400 and 500 fpm. If the outdoor air damper is sized based on this velocity (i.e. the damper is the same size as the louver) then the performance characteristic from Figure 1 would be $\alpha = 25$. The air pressure drop across the damper is simply too low to get any suitable control. An opposed blade damper would do better, but would still offer very poor control.

Figure 2. Indoor Handling Unit Example



This can be resolved by moving the damper location to the air handling unit itself. Now the damper can be properly sized to give optimum performance.

Dampers used for return air and outdoor air are also called upon to mix the two air streams and control flow rates. For flow rate control, opposed blade dampers are preferred because the performance curve is more linear. For mixing, parallel dampers are preferred because the two air streams can be directed into each other. Typically, parallel dampers are carefully selected for air handling units to promote better mixing.

Another common practice is to divide the outdoor air damper bank into smaller dampers that are sized to bring in minimum outdoor air quantities while providing balance for economizer operation. The smaller dampers can be sized at a higher velocity to give a more linear performance. However, this can only be done if the damper is separated from the inlet louver.

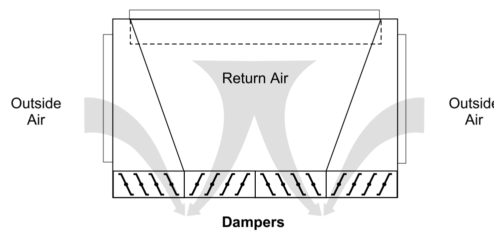
Rooftop Systems

Rooftop systems face several challenges with outdoor air volume control. The damper location and sizes are constrained by the unit geometry. Unlike indoor air handlers, rooftop systems are directly exposed to the elements (sun, wind, rain, etc.) which can have an impact on outdoor air volume control.

As with indoor air handling unit systems, the outdoor air inlets must be sized to avoid entrainment and to offer control. Dampers simply mounted on the side of the unit cannot meet the two requirements of avoiding entrainment and volume control. One solution is to use hoods over the inlets. The hood can resolve entrainment and allow the damper to be sized for performance in much the same way as an indoor air handler. Another solution is to locate louvers away from the dampers to resolve entrainment (Figure 3). This too allows the dampers to be properly sized for performance and can be more architecturally pleasing than hoods.

Figure 3. McQuay Rooftop System Economizer Air Flow

Top View



Return Fans Can Help Control Outdoor Air Volume

The use of a return air fan or exhaust fan can have a direct impact on the ability of the rooftop equipment to control outdoor air volume. The airflow through the outdoor air inlet is created by the pressure differential between ambient air and the negative pressure in the mixing plenum.

When return air fans are used, the pressure differential is typically in the range of -0.2" w.c. This pressure draws air back to the rooftop unit and helps to maintain positive building pressurization. With exhaust fans, return air is drawn back by the supply fan and resulting pressure in the mixing box is –0.7" w.c. This large pressure differential across the damper causes α to equal 100. As a result, elaborate control sequences are required to operate the exhaust fan so that it maintains building pressurization.

Testing And Balancing Can Be Difficult

If the outdoor airflow could be measured, then the control system could be programmed to account for the non-linear relationship between damper position and airflow. It is very difficult to "factory set" the controls because the damper performance changes depending on the site conditions. This is particularly true for exhaust fan applications where the return static pressure varies with each project. Field calibrating the controls requires measuring the actual airflow.

Unlike an indoor air handling unit or built up system, there is no easy way for a Testing and Air Balancing (TAB) contractor to measure the outdoor air rate on rooftop systems. The turbulence caused by the inlet louvers makes it nearly impossible to get accurate, consistent readings. One possible way to measure outdoor airflow on a rooftop unit would be to build additional ductwork on the inlet so the air velocity could be measured. Unfortunately, this approach is cost prohibitive and the ductwork itself would affect the outcome by creating an abnormal pressure drop.

Wind Affects Performance
Wind is another variable that can affect outdoor air volume. A 10 mph wind travels at 880 fpm. This is actually faster than the design velocity through the louver. The velocity pressure of a 10 mph wind is 0.04" w.c. Again, this is a significant portion of the pressure differential between outside and the mixing box.

Rooftop units are more susceptible because they are exposed on the roof. Even if the control system offsets for damper performance, it cannot account for the wind.

Directly Measure The Outdoor Air Volume

Up until now, the discussion has focused on dampers as they relate to bringing in outside air. What we have demonstrated is that the damper position doesn't necessarily determine outdoor air volumes because the relationship between the two is indirect and dependent on several other factors. Therefore, while the damper position may be known, the only way to accurately determine the outdoor air volume is to directly measure it. If this can be accomplished, then the information can be used by a unit controller to correctly position the outdoor air damper.

Direct measurement is particularly important for rooftop VAV systems. Minimum requirements prescribed in ASHRAE Standard 62.1-1999 provide the added challenge for these systems to maintain minimum ventilation rates throughout their supply air operating range. The issue has culminated into an almost universal recognition that ventilation rate measurement is needed for VAV systems to help make sure that outdoor air quantities are maintained to within no less than 90% of required levels throughout the supply air operating range.

The Advantages Of Directly Measuring Outdoor Air Volume
The first and most important advantage to directly measuring outdoor air volume is that the variable that needs to be controlled (outdoor air volume) becomes known – just like the damper position is known – and the relationship between the two becomes known. This, in turn, translates into good IAQ without the energy expense of excess ventilation.

In addition, a system that directly measures outdoor air volume is dynamic. It can respond to changes in the rest of the HVAC system, which can include anything from dirty filters to a broken return air fan.

Conclusion

ASHRAE Standard 62.1-1999 provides the tools for determining minimum ventilation rates for a building project. It is up to the consulting engineer to determine the optimum method used to consistently maintain these rates without excess. Along with proper equipment design and layout, direct outdoor air measurement can be an important tool in achieving this goal — particularly with rooftop VAV systems. For more information, contact your local McQuay Representative.

DesignFlow™ Provides Direct Outdoor Air Measurement For McQuay Rooftop VAV Systems

Measuring air volumes has traditionally been tricky – particularly for rooftop VAV systems at part load conditions. To date, most of the technology used for this purpose requires measuring the air velocity through a fixed area with pressure sensors or hot wire anemometers. The values are then converted to airflow by assuming that a uniform flow pattern exists across the entire fixed area at all operating conditions.

While repeatable under ideal, full flow conditions, these assumptions often cannot be counted on under field conditions. System dynamics and installation limitations cause turbulence, pressure variations and uneven flow patterns that prohibit accurate, repeatable measurement. Varying atmospheric conditions (wind, altitude, humidity, etc.) can also affect the accuracy of these systems. Finally, the sensors themselves can be suspect and lead to inaccurate airflow calculations.

McQuay's solution is the patent pending DesignFlow™ Precision Outdoor Air Control System. DesignFlow is the only factory-installed system designed to specifically provide accurate ventilation control for rooftop VAV systems to support compliance with the minimum ventilation requirements of ASHRAE Standard 62.1-1999.

DesignFlow responds directly to the total mass volume of air flowing through the outdoor air intake area. In doing so, it is indifferent to uneven flow profiles, air turbulence and pressure variations. In addition, DesignFlow's unique, patent pending design automatically corrects to terms of standard air without relying on added conversion calculations for varying atmospheric conditions. The accurate, consistent airflow measurement provided by DesignFlow is used by McQuay's new MicroTech II™ rooftop controller to adjust outdoor air intake dampers and maintain minimum ventilation quantities.

Proven Accuracy

McQuay enlisted the services of Intertek Testing Services, Inc. (ITS), to evaluate and verify the performance of the DesignFlow system. ITS is a respected independent testing laboratory that is well known for its expertise in the performance

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testing of HVAC&R products and systems. ITS is also known for its internationally accepted ETL product safety certification programs.

In rigorous, repetitive testing, ITS found the DesignFlow system to consistently measure outdoor air intake volume at >95% of the design set point - substantially higher accuracy than the 90% industry goal. In fact, the maximum test deviation was <2.5%. A letter verifying test results is available by contacting your local McQuay sales representative.

Benefits Of The DesignFlow System

Energy Efficient Operation

Because of the reliability and accuracy of the DesignFlow system, outdoor air intake volumes can be set at just the right value for the most energy efficient control. By supplying "just enough" outdoor air, the energy dollars needed to treat the ventilation air supply are minimized.

Reduced Design And Installation Costs

DesignFlow is fully engineered and factory-installed to provide optimum system operating performance while minimizing installation costs. As part of a complete MicroTech II unit control system, the engineer needs only to specify a factory-installed ventilation airflow measuring and control system with the performance characteristics of DesignFlow. No additional components or design engineering are necessary. For the contractor, only customary commissioning is required, with no added installation expense.

Contact your local McQuay Representative for more information on direct outdoor air measurement for McQuay rooftop VAV systems using DesignFlow.

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