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ENGINEERING

SYSTEM SOLUTIONS

In this issue, we describe the benefits of two-pipe unit ventilator system design for schools, and provide an approach to achieve similar performance to four-pipe alternatives. More and more, modern construction is making two-pipe unit ventilator system design a viable, cost saving approach to school design.

For more than 80 years, school buildings have relied on AAF®-HermanNelson® unit ventilators from McQuay to keep classrooms comfortable and promote better learning. Our second article highlights some of the benefits that make this system vital in today's classroom.

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 McQuay Unit Ventilators 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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Four-pipe Unit Ventilator Performance With A Two-pipe Design

Unit ventilators have been providing a healthy, comfortable environment that encourages learning in classrooms for over 80 years. Unit ventilators were designed specifically for the unique challenges presented by school buildings and offer many features that are important to school design:

- **Indoor air quality.** Unit ventilators are the only system designed to provide up to 100% outdoor air *directly* into each classroom. ASHRAE Standard 62.1-1999 requires 15 cfm of outdoor air per person in a classroom. Therefore, a classroom with 30 students would require a ventilation rate around 450 cfm. The typical supply air volume for a classroom is 750 to 2,000 cfm. While some centralized systems can accommodate this high percentage of outdoor air, the cost of doing so can be significantly higher in terms of equipment, building materials, and operating expenses.
- **Decentralized approach.** A unit ventilator system provides a dedicated unit for each classroom. This allows some classrooms to be in heating while others are in cooling. When a classroom is not in service, the outdoor air can be minimized to reduce operating costs. If a unit ventilator requires service, only one classroom is affected.
- **Flexibility.** Unit ventilators can be either chilled water or DX cooled. The DX can be self-contained or remote. They can be electric, hot water or steam heated. Water source heat pump and ground source heat pump versions are also available. The unit can be located in the exterior wall below the window or ceiling hung. Self-contained units are floor only.

4 Pipe System

A common system design for unit ventilators is hot water heat and chilled water cooling. This design offers many benefits. The school can be heated by natural gas and an efficient chiller can accomplish the cooling. The chiller size can be based on the block load and not the connected load (Diversity can be applied). Having both hot water and chilled water available allows simultaneous heating and cooling throughout the school. It also allows dehumidification by means of reheat within the classroom.

This is a good way to provide an excellent learning environment. However, the system requires that two sets of pumps and two sets of insulated piping be installed throughout the school. Also, dehumidification by means of reheat can raise the operating expenses for the school.

2 Pipe Alternative

A two-pipe system reduces the first cost and operating cost of the system by eliminating the need for one set of

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insulated pipes and one set of pumps. The equipment cost for the unit ventilator is also reduced because there is only one coil required. Overall, the construction costs for a two-pipe system can be as much as 25% less than a four-pipe arrangement.

What Are The Differences?

The first cost and operating cost savings are desirable, but some performance is sacrificed with the two-pipe concept. It is no longer possible, on the same loop, to have one unit ventilator in mechanical cooling (economizer cooling is available) while another is in heating. Also, dehumidification by means of reheat is not possible.

How To Minimize The Impact

It is possible to minimize the impact of the two-pipe concept by modifying the system design. With a well-designed system, the changeover from heating to cooling can be accomplished in under 20 minutes.

Modern Construction Is The First Step

The key issue surrounding two-pipe changeover systems is how well they perform in moderate weather. What if the classroom on the north side requires heating while the classroom on the south side needs cooling?

Modern construction plays a key role in making the job easier for a two-pipe system. Today's school buildings are more tightly sealed with heavy insulation and good windows, reducing infiltration and minimizing load swings. This leaves two loads for the unit ventilator system to address – outdoor air and internal heat gains – both of which are constant in all classrooms regardless of the weather, and both of which can be addressed by a two-pipe system.

School layout and orientation may also play a key role in assessing how the school will perform during moderate weather. The orientation of a school may be such that one block or wing of classrooms will behave differently than another block of classrooms (i.e. classrooms facing East will get morning sun while classrooms facing South will get afternoon sun). Once the differences have been identified, then a solution can be sought. In many cases, the solution may be as simple as having two loops – one serving each block of classrooms.

Choose The Right Boiler

A high efficiency (over 90%) condensing boiler is the best choice. In addition to the obvious benefit of lower operating costs, condensing boilers can be selected in modules to provide staging and redundancy.

In a two-pipe system, the coil in the unit ventilator needs to be selected to meet the more demanding role of cooling. As a result, the coil will be oversized for heating, which could lead to control problems and poor space temperature control. By using a condensing boiler, the heating loop can be operated at 80°F and modulated up with an outdoor air reset controller. The lower temperature will allow good space temperature control and improve the changeover time from heating to cooling.

Other benefits of condensing boilers include a smaller footprint and no need for circulating boiler pumps – both of which reduce the size requirement for the mechanical room. In addition, a condensing boiler allows quick changeover because it can accept low entering water temperatures without damage.

Pump Design And Face And Bypass

Face and bypass offers the best space temperature and humidity control and the best protection against coil freeze up. The flow through the coil is always constant ensuring good dehumidification in the summer and minimal freeze potential in the winter. Face and bypass also simplifies the pump design. The following are pump design options for a two-pipe system:

1. Good

Use a single speed pump with face and bypass. Design the chilled water for 44°F supply water temperature and 10°F temperature difference. The heating will then operate with 80°F water temperature reset upward from an outdoor air sensor at the same flow as the chilled water rate.

2. Better

Use a two speed pump with face and bypass. For chilled water, use the pump on high speed with 44°F supply water temperature and 10°F temperature difference. For heating, operate the pump on low speed with 80°F water temperature reset upward from an outdoor air sensor. The two-speed pump will offer the school excellent operating savings and not sacrifice climate control.

3. Best

Use a variable speed drive on the pump with face and bypass. The unit ventilators will need to be able to close the water valve when the air is in full bypass. As the unit ventilator valves close off, the variable speed drive will slow the pump to meet the required flow. In heating mode, the variable speed drive can be limited to half flow maximum. For chilled water, use 44°F supply water temperature and 10°F temperature difference. For heating, use an 80°F water temperature reset upward from an outdoor air sensor.

ASHRAE Standard 90.1-1999 requires hydronic systems with 10 or more pump horsepower to be variable flow. With face and bypass arrangements, end of cycle valves should be used to allow for pump savings.

What About Dehumidification?

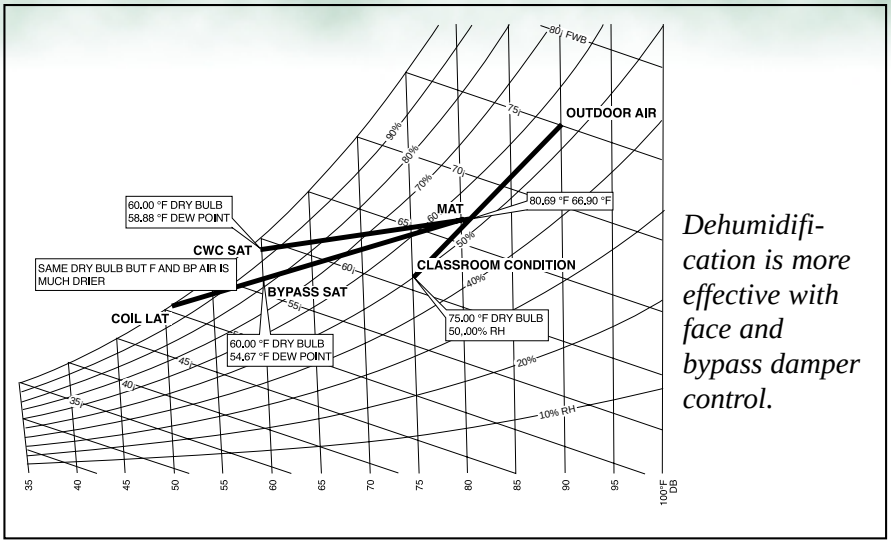
In southern climates, dehumidification is critical to maintaining a good learning environment. ASHRAE 62.1-1999 recommends maintaining the relative humidity between 30 and 60%. Without simultaneous heating and cooling, this may appear to be difficult.

Again face and bypass is the key. By using face and bypass, all air that passes through the cooling coil gets dehumidified because the coil surface is always below the dew point. When a control valve is used in lieu of face and bypass, sensible temperature is maintained but dehumidification is given up.

Dehumidification is more effective with face and bypass damper control.

A draw through design also helps with dehumidification. The air passes first through the coil, and then through the fan creating an even flow over the entire coil surface to improve dehumidification. This is the way central air handling stations are designed.

Lowering the supply air volume will further enhance the dehumidification capabilities of face and bypass. The colder the air leaving the coil, the more dehumidification the classroom receives. Advanced controls, such as McQuay's Microtech‘ unit controller, are required to maintain the correct amount of outdoor air and the classroom temperature while operating at reduced supply air volumes.



Dehumidification is more effective with face and bypass damper control.

ASHRAE Standard 90.1-1999 and Changeover systems

Two-pipe changeover systems are energy efficient in that they cannot be heating and cooling at the same time. However, the actual changeover requires changing the fluid temperature, which does waste energy. To address this, ASHRAE STD 90.1-1999 has three requirements:

1. There must be a deadband in the changeover of at least 15°F outdoor air temperature.
2. The system must be designed and installed with controls that allow operation in one mode for at least 4 hours before changing back to the other mode.
3. Reset controls are provided that allow the hot water and chilled water setpoints to be no more than 30°F apart at changeover.

The first requirement can be met with economizers. For example, a deadband of 15°F from 50°F ambient to 65°F ambient meets the requirement. For the 4 hour deadband, all the classrooms will behave approximately the same since two-thirds of the load is the ouside air load and internal heat gains. Finally, for the 30°F deadband, resetting the chilled water up to 50°F and the hot water down to 80°F will meet the requirement.

Conclusion

A two-pipe unit ventilator system design makes sense in schools built or remodeled using modern construction techniques. In these schools, the classroom load profiles will be dominated by outdoor air loads and internal heat gains. Both can be accommodated with a two-pipe unit ventilator system that uses face and bypass damper control and a draw through design. The result can be significant installed and operating cost savings versus central systems or four-pipe valve control unit ventilator systems, as well as the added advantage of effective humidity control. Add to this the inherent unit ventilator advantage of bringing outside air directly into the classroom, and the two-pipe system may deliver the best of both worlds – an environment that encourages learning for students and teachers at significantly lower cost for school administrators.

Creating A Better Climate For Learning–AAF®-HermanNelson® Unit Ventilators

For more than 80 years, school buildings have relied on AAF®-HermanNelson® unit ventilators from McQuay to keep classrooms comfortable and promote better learning. From the beginning, AAF-HermanNelson unit ventilators have been designed and built with the idea that properly ventilated classrooms increase the mental and physical capabilities of students of all ages, and provide a better environment for learning.

AAF-HermanNelson unit ventilators are as vital in today's classroom as they were more than 80 years ago. New and remodeled schools are sealed tight to meet energy efficiency codes, creating the need for more classroom ventilation to combat airborne pollutants – the causes of poor indoor air quality. The added ventilation, along with a longer school year that extends into both heating and cooling months, has created the need for more humidity control.

While they have been improved over the years to meet these and other challenges, the benefits that have made AAF-HermanNelson unit ventilators the classroom ventilation system of choice still apply:

Promotes Good Classroom IAQ That Encourages Learning

Unit ventilators are the only system designed to provide up to 100% outdoor air *directly* into each classroom to help meet ASHRAE Standard 62.1-1999 ventilation requirements. Face and bypass damper control and the draw through design of AAF-HermanNelson unit ventilators provide precise, efficient temperature and humidity control to maintain comfort conditions in the classroom. In addition, full-length filter helps ensure that all air delivered into the classroom is filtered.

Because they reside in the classroom, AAF-HermanNelson unit ventilators are designed to be exceptionally quiet. Recent enhancements enable the units to achieve "whisper quiet" operation while delivering rated air. These include a new fan wheel design that incorporates fluid dynamics, an expanded discharge opening that minimizes air resistance as air exits the unit, and a new rigid fan motor mount that minimizes vibration.

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Economical

In addition to the economies of a decentralized system approach, each unit ventilator can be operated for about the same cost as lighting two 100-watt light bulbs.

Flexible

Added to the configuration flexibility of the units are the benefits of individual classroom control and 0 to 100% fresh air operation that provide room to grow by allowing an increase in class size to be accommodated without system changes.

Reliable

AAF-HermanNelson unit ventilators are designed to provide years of reliable service. Quality components, scratch and dent resistant exterior, and impenetrable interior withstand classroom bumps, bruises, and curiosity. Easy access to unit interior and components encourages regular maintenance to ensure peak performance.

MicroTech™ Direct Digital Controls ensure the correct operating sequence without human intervention while allowing for easy adjustments and remote monitoring.

Aesthetically pleasing and environmentally friendly

For classroom aesthetics, AAF-HermanNelson unit ventilators feature a quality, environmentally friendly finish that is available in architecturally pleasing colors designed to match any decor. A trim profile requires minimum classroom space while delivering an environment that encourages learning.

Look to the school experts at McQuay for your new or remodeled school project. See how directly adding fresh air into your classrooms using AAF-HermanNelson unit ventilators can create a better climate for learning.

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