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CO2-based Ventilation Control In Education Facilities

Ventilation is an important part of maintaining a comfortable, healthy, productive environment for students and faculty. One study found that 86% of classrooms had incidences of inadequate ventilation,[1] and a California study found that classrooms had inadequate ventilation 42% of the time.[2] Improper ventilation can have a negative impact on student health and performance, increase the risk from litigation, and energy usage.

CO2-based ventilation control (also called demand controlled ventilation or DCV) is the solution. This building control strategy optimizes the outside air intake based on measured ventilation rates. Optimum means the building will not be under- or over-ventilated. The result of under-ventilation is poor indoor air quality. Over-ventilating wastes energy because the air often must be conditioned before being sent into the building.

Indoor carbon dioxide (CO2) levels form the basis of ventilation control. There is a clearly defined relationship between indoor CO2 levels and per person ventilation rates. This relationship is recognized by ASHRAE, ASTM, and the EPA.

Students and faculty breathe in oxygen and exhale CO2. Outdoor air or ventilation has a very low and typically constant CO2 content and, when introduced into a room, dilutes the CO2 exhaled by people. High indoor CO2 levels mean there is not enough ventilation entering the room. Low CO2 levels indicate over-ventilation.

The indoor CO2 reading allows the HVAC system's outdoor air intakes to modulate based on the building's actual load. Maintaining the proper indoor CO2 level ensures required ventilation rates are met.

CO2-based ventilation control should be applied in:

- Classrooms
- Offices
- Auditoriums
- Gymnasiums
- Cafeterias
- Lobbies

The benefits are:

- Ensures a comfortable, healthy indoor environment
- Increases funding
- Improves student performance
- Reduces risk
- Saves energy

Ensures Comfortable, Healthy Environment
Numerous studies have linked proper ventilation to a healthy indoor environment. For example, a Lawrence Berkeley National Laboratories research paper on indoor air quality, ventilation, and health symptoms in schools found that headaches, dizziness, drowsiness, respiratory and

throat irritation, and lack of concentration symptoms increased with high CO_2 concentrations (i.e. low ventilation rates).[3]
A recent EPA article stated that student use of inhalers dropped 50% after IAQ improvements were made in two San Francisco schools.[4]
Ventilation also has a significant impact on sick building syndrome symptoms and perceived air quality.[5]

Proper ventilation helps to ensure a comfortable and healthy environment for students and faculty. CO_2-based ventilation control is the best method to ventilate a building.

Increases Funding
Many K-12 school districts receive state funding based on the student-days or average daily attendance (ADA). Inadequate ventilation has been shown to increase absenteeism by 10 to 20%.[6] Using CO_2 control to maintain proper ventilation can reduce absenteeism which increases state funding. As you can see in the table below, even a small reduction in absenteeism can substantially increase funding.

Funding Benefit from Improved Absenteeism

of Students = 100,000
Average daily attendance = 95%
Annual funding per student = $5,000

Absenteeism Reduction	Increased School Funding
5%	$1,250,000
10%	$2,500,000
15%	$3,750,000
20%	$5,000,000

Improves Student Performance
According to a recent study published in the ASHRAE Journal, a school's indoor environment should be given as much importance as teaching methods because student scores increased significantly when the indoor CO_2 level was kept at or below 1,000 ppm.[7] This is backed up by a European study where student scores were lower and health symptom responses higher in classrooms with high CO_2 levels (ie low ventilation rates).[8]

This is why Sundersingh and Bearg stated in their article titled "Indoor Air Quality in Schools (IAQ): The Importance of Monitoring Carbon Dioxide Levels": "CO_2 monitoring is a must for maintaining high quality in the classroom."[9]

Reduces Risk
Having a comfortable, healthy environment reduces the possibility of an illness blamed on poor indoor air quality. So, this alone reduces the school's risk.

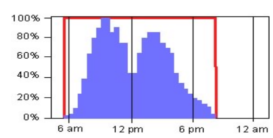
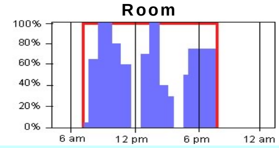
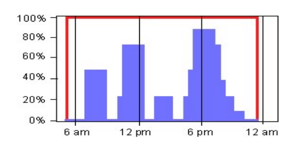
Second, as stated previously, there is a clearly defined and recognized relationship between indoor CO_2 levels and ventilation rates. Documenting indoor CO_2 levels shows the building is in compliance with codes and standards.

How does school administration respond to an illness blamed on poor indoor air quality if there is no means of measuring ventilation in the building? Performing an IAQ study weeks after the reported incident does little to show compliance. However, using CO_2-based ventilation control gives administrators a way of proving that ventilation codes and standards were being met during the time in question.

Energy Savings

CO_2-based ventilation control delivers energy savings when compared to the alternative fixed ventilation approach. Fixed ventilation assumes that the building is always fully occupied, so the maximum prescribed amount of outside air enters the building during equipment operating hours. Using CO_2, ventilation is based on the actual ventilation load of the building.

For example, let's examine a classroom designed to hold 25 students. Using the alternative fixed ventilation approach, enough outside air is brought in for 25 students whether there are 5 or 25 present. When only 5 students are in the room, the fixed ventilation method brings in more outside air than is required.
In this example, CO_2-based ventilation control would reduce the outside air intake to bring in the

CO2 DCV Energy Savings Analysis			Office Space		Class/Meeting/Lecture Room		Theater/Conference/Gym	
% of Design Occupancy (blue); Fixed Ventilation Schedule (red)								
Floor Area			10,000 sq ft		800 sq ft		10,000 sq ft	
Ceiling Height			10 ft		10 ft		30 ft	
Design Occupancy			100 people		30 people		1000 people	
Ventilation Rate (cfm/person)			20 cfm/person		15 cfm/person		15 cfm/person	
Base Ventilation Rate For DCV			30% Of Design		30% of Design		30% Of Design	
Heating/Cooling			NGas/Electric		NGas/Electric		NGas/Electric	
Ventilation Schedule			Weekdays 5:30 AM - 10:00 PM Low Saturday Occupancy		Weekdays 7:30am - 9:00pm Unoccupied Weekends		7 days per week	
Location	**Fuel**	**Cost**	**Annual Savings**		**Annual Savings**		**Annual Savings**	
			Total $	**$/sq ft**	**Total $**	**$/sq ft**	**Total $**	**$/sq ft**
Miami, FL	Gas$/therm	$ 0.804	$ 1,237.00	$ 0.15	$ 169.00	$ 0.39	$ 12,664.00	$ 1.27
	El $/kWh	$ 0.074						
Baltimore, MD	Gas$/therm	$ 0.798	$ 1,995.00	$ 0.22	$ 271.00	$ 0.58	$ 17,603.00	$ 1.76
	El $/kWh	$ 0.079						
Boston, MA	Gas$/therm	$ 0.104	$ 2,088.00	$ 0.23	$ 283.00	$ 0.62	$ 18,729.00	$ 1.87
	El $/kWh	$ 0.798						
Chicago, Il	Gas$/therm	$ 0.622	$ 1,756.00	$ 0.19	$ 235.00	$ 0.52	$ 18,001.00	$ 1.80
	El $/kWh	$ 0.088						
St Louis, MO	Gas$/therm	$ 0.681	$ 1,703.00	$ 0.19	$ 234.00	$ 0.52	$ 17,243.00	$ 1.72
	El $/kWh	$ 0.070						
Houston, TX	Gas$/therm	$ 0.554	$ 1,213.00	$ 0.14	$ 162.00	$ 0.38	$ 12,549.00	$ 1.25
	El $/kWh	$ 0.076						
Los Angeles, CA	Gas$/therm	$ 0.762	$ 581.00	$ 0.06	$ 76.00	$ 0.17	$ 5,998.00	$ 0.60
	El $/kWh	$ 0.147						
Portland, OR	Gas$/therm	$ 0.705	$ 1,339.00	$ 0.14	$ 178.00	$ 0.27	$ 11,530.00	$ 1.15
	El $/kWh	$ 0.065						
Toronto, Ont	Gas$/therm	$ 0.722	$ 2,213.00	$ 0.24	$ 294.00	$ 0.64	$ 22,527.00	$ 2.25
	El $/kWh	$ 0.088						

correct amount for 5 students. On a hot summer day or cold winter morning, the opportunity to reduce the amount of outside air saves money because it does not have to be conditioned.

Typical payback period is between 6 and 18 months. There are few technologies that ensure compliance to building codes and standards and save money.

GE Sensing-Telaire's Ventulator energy analysis program calculates the expected energy savings when using ventilation control versus fixed ventilation. Also, check with the local utility company about rebates for using CO2 sensors in your educational facility.

Other Benefits

CO2-based ventilation control offers other direct and indirect benefits:

- CO2 control doesn't care where the outdoor air enters the building. For example, most schools have doors that constantly open and close allowing outdoor air into the building. With CO2 control, this additional source of ventilation is accounted for. Fixed ventilation approaches like using outdoor airflow monitoring stations cannot detect such natural ventilation resulting in additional over-ventilation.
- Space CO2 sensors measure the ventilation that gets down to where the students are located. Thus, ventilation effectiveness is taken into account.
- CO2 control detects problems with the ventilation system. For example, improper CO2 levels can indicate a broken damper motor or linkage.
- LEED's gives one point to schools of a certain size and occupant density for using CO2 control.
- ASHRAE 90.1 requires the use of CO2 control in certain applications.
- ASHRAE's Humidity Control Design guides shows that outdoor air ventilation is the source of 60% of the humidity inside the building.[10] Using CO2-based ventilation control to reduce the outdoor air intake when the building is not fully occupied results in reduced humidity control because less moisture enters the building.

As you can see, CO2 ventilation control offers a variety of benefits to educational facilities. Few technologies ensure a comfortable environment, reduce absenteeism/increase funding, help improve student performance, reduce risk, and save energy.

To learn more, contact GE Sensing at (800) 833-9438 or visit http://www.gesensing.com/telaireproducts .

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