TELAIRE®

CO_2-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.

CO_2-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 (CO_2) levels form the basis of ventilation control. There is a clearly defined relationship between indoor CO_2 levels and per person ventilation rates. This relationship is recognized by ASHRAE, ASTM, and the EPA.

Students and faculty breathe in oxygen and exhale CO_2. Outdoor air or ventilation has a very low and typically constant CO_2 content and, when introduced into a room, dilutes the CO_2 exhaled by people. High indoor CO_2 levels mean there is not enough ventilation entering the room. Low CO_2 levels indicate over-ventilation.

The indoor CO_2 reading allows the HVAC system's outdoor air intakes to modulate based on the building's actual load. Maintaining the proper indoor CO_2 level ensures required ventilation rates are met.

CO_2-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.

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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 (i.e. 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.

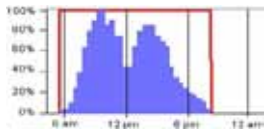
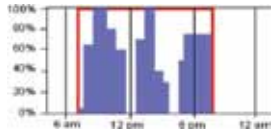
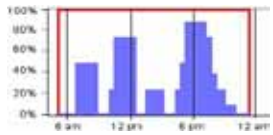
In this example, CO_2-based ventilation control would reduce the outside air intake to bring in the correct amount for 5 students. On a hot summer day or cold winter morning, the opportunity to reduce the amount of outside air saves money because it does not have to be conditioned.

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

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 CO_2 sensors in your educational facility.

CO_2-based Ventilation Control in Education Facilities

CO_2 DCV Energy Savings Analysis

	Office Space	Class/Meeting/ Lecture Room	Theater/Conference/Gym
% of Design Occupancy / Fixed Ventilation Schedule			
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 Total $	Annual Savings $/sq ft	Annual Savings Total $	Annual Savings $/sq ft	Annual Savings Total $	Annual Savings $/sq ft
Miami, FL	Gas$/therm El $/kWh	$ 0.804 $ 0.074	$ 1,237.00	$ 0.15	$ 169.00	$ 039	$ 12,664.00	$ 1.27
Baltimore, MD	Gas$/therm El $/kWh	$ 0.798 $ 0.079	$ 1,995.00	$ 0.22	$ 271.00	$ 058	$ 17,603.00	$ 1.76
Boston, MA	Gas$/therm El $/kWh	$ 0.104 $ 0.798	$ 2,088.00	$ 0.23	$ 283.00	$ 062	$ 18,729.00	$ 1.87
Chicago, Il	Gas$/therm El $/kWh	$ 0.622 $ 0.088	$ 1,756.00	$ 0.19	$ 235.00	$ 052	$ 18,001.00	$ 1.80
St Louis, MO	Gas$/therm El $/kWh	$ 0.681 $ 0.070	$ 1,703.00	$ 0.19	$ 234.00	$ 052	$ 17,243.00	$ 1.72
Houston, TX	Gas$/therm El $/kWh	$ 0.554 $ 0.076	$ 1,213.00	$ 0.14	$ 162.00	$ 038	$ 12,549.00	$ 1.25
Los Angeles, CA	Gas$/therm El $/kWh	$ 0.762 $ 0.147	$ 581.00	$ 0.06	$ 76.00	$ 017	$ 5998.00	$ 0.60
Portland, OR	Gas$/therm El $/kWh	$ 0.705 $ 0.065	$ 1,339.00	$ 0.14	$ 178.00	$ 027	$ 11,530.00	$ 1.15
Toronto, Ont	Gas$/therm El $/kWh	$ 0.722 $ 0.088	$ 2,213.00	$ 0.24	$ 294.00	$ 064	$ 22,527.00	$ 2.25

Other Benefits

CO_2-based ventilation control offers other direct and indirect benefits:

- CO_2 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 CO_2 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 CO_2 sensors measure the ventilation that gets down to where the students are located. Thus, ventilation effectiveness is taken into account.
- CO_2 control detects problems with the ventilation system. For example, improper CO_2 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 CO_2 control.
- ASHRAE 90.1 requires the use of CO_2 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 CO_2-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, CO_2 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.

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