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Improve Learning, Save Energy & Reduce Risk in Learning Spaces with CO_2 based Ventilation Control

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Proper ventilation is an important part of maintaining a comfortable, healthy, productive environment for students and faculty. That is the inescapable conclusion of many studies in to the classroom environment across the globe. Yet, one study found that most classrooms had significant incidences of inadequate ventilation,[(1)] showing considerable occupied periods above the now regulated concentration value of 1,500 parts per million (ppm) With statistics like this the question becomes, what is the best way to monitor and control ventilation in the classroom?

Automatic CO_2-based ventilation control is the better solution, but the existing building stock may not be suitable for mechanical ventilation, or it may be cost prohibitive. Either way, a monitoring solution can be implemented that either alerts staff to the condition for manual intervention, or control can be integrated in to mechanical systems. Automatic systems include natural ventilation (automatic windows or louvres) or fan based mechanical systems (sometimes known as demand controlled ventilation or DCV). A DCV building control strategy optimizes the outside air intake based on measured ventilation rates: the result of under-ventilation can be poor indoor air quality; conversely over-ventilating wastes energy because the air often must be conditioned before being sent into the building.

We all know that during the process of breathing people take in air and exhale more CO_2. Outdoor air has a low and typically constant CO_2 content (typically 400ppm) 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 possible over-ventilation (the exception is when all the windows are open to free cool a space or free cooling is demanded and available from outside air).

The proposal to use CO_2 (Carbon Dioxide) as a tracer gas for indication of human bio-effluent output is well documented[(2)], so we can modulate the amount of outside air to meet the demands of the controlled space. This should not be confused with the CO_2 emissions, although it should be noted the use of this methodology will reduce energy consumption against a constant supply scenario, and hence reduce emissions.

The American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) recommend control levels should be set to try and maintain 1000 ppm [(4)] (equivalent to a dilution rate of approx 10 litres per adult per second) above which people begin to experience problems with lethargy and headaches, and the view is backed by much independent research such as that done by Myhrvold, Olsen and Lauridsen in1996[(3)] in schools and colleges, and guidelines by the like of CIBSE and VDE.

Numerous studies link 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).[(5)] A recent EPA article stated that student use of inhalers dropped

50% after IAQ improvements were made in two San Francisco schools.[6] Ventilation also has a significant impact on sick building syndrome symptoms and perceived air quality.[7]

Proper ventilation helps to ensure a comfortable and healthy environment for students and faculty. CO2-based ventilation control is the best method to ventilate a building.

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.[8] 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).[9]

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. As stated previously, there is a clearly defined and recognized relationship between indoor CO2 levels and ventilation rates. Documenting or proving indoor CO_2 levels shows the building is in compliance with codes and standards.

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 all equipment operating hours. Using CO_2 based control ventilation is based on the actual ventilation load of the building.

CO_2 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 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 (Leadership in Energy and Environmental Design) certification programme points are available when using CO_2 based ventilation control.

In conclusion it can be seen that considerable energy savings are to be made in any space that has a variable occupancy where the alternative is a fixed volume ventilation system, or where the primary driver is a need for the occupants to be thinking clearly.

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

References:

1. Ventilation and Indoor Air Quality in Schools – Guidance Report 202825 Building Research Technical Report 20/2005 March 2006 Paul Ajiboye, Martin White, Hilary Graves and David Ross.
   Building Research Establishment for Office of the Deputy Prime Minister: London
2. The Relationship between indoor air quality and carbon dioxide. (Pesily, Proceedings of the 7th International Conference on Air Quality and Climate, July 21–26, Nagoya, Japan.) (1996)
3. Indoor environment in schools: Pupils' health and performance in regard to CO2 concentrations, (Myhrvold, A. N., E. Olsen, and O. Lauridsen., Proceedings of the 7th International Conference on Air Quality and Climate, July 21–26, Nagoya, Japan.) (1996)
4. ANSI/ASHRAE Standard 62.1 (American Society of Refrigeration and Air Conditioning Engineers, GA, USA) (2004)
5. "Indoor Air Quality, Ventilation, and Health Symptonms in Schools: an Analysis of Existing Information" Lawrence Berkeley National Laboratory LBNL-48287: Joan Daisey, William Angell, Michael Apte Indoor Air; Volume 13, Number 1, March 2003, pp. 53-64 (12)
6. "Does Indoor Air Quality in Schools Impact Student Performance?"
   US EPA Indoor Environments Division School Business Affairs (April 2004; Vol. 70, Num. 4: 18-20)
7. "Summary of Human Responses to Ventilation: Pupils Health & Performance In Regard To CO2 Concentrations" Seppanen O.A., Fisk W.J. Indoor Air (2004; 14 Suppl 7:102-18)
8. "Research Report on Effects of HVAC on Student Performance"
   Wargocki, Pawel; Wyon, David
9. Indoor Air Quality and Student Performance"
   US Environmental Protection Agency, Indoor Environments Division EPA (Doc. 402-F-00-009, August 2000)
10. Humidity Control Design Guide
    Lew Harriman, Geoff Brundrett, Rienhold Kittler
    American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE), 2001, pg. 138