

How to implement air quality sensors

The cost of running a building's ventilation system can account for as much as 30% of its total running costs. The easiest way to save costs is to reduce the length of time a ventilation system operates, but this has to be balanced against the comfort of people who use the building.

Ventilation systems controlled by demand are the most effective at maintaining good levels of indoor air quality, without using excessive amounts of energy. In industrial, commercial and public buildings, these systems are usually based on air quality sensors, and the most commonly used are carbon dioxide (CO₂) sensors.

The business case

The cost of installing a CO₂ sensor on existing air handling plant depends on whether the plant can accept an electronic control signal. If it can, a sensor is likely to cost around £300 to buy and fit. If the existing air handling plant control needs to be modified slightly to take electronic signals, the outlay could be around £600.

The relatively low cost of buying and installing a CO₂ sensor means that you could recoup the cost in as little as six months.

The technology

We breathe out CO₂ and so, if we are inside a building, air needs to be able to circulate to stop that CO₂ from reaching uncomfortable or unhealthy levels.

The level of CO₂ in an environment is measured in parts per million (ppm). You can see typical CO₂ levels and their effects on our comfort or health in Table 1.

Table 1 Effects of CO₂ levels on human health

CO ₂ level (ppm)	Condition
350-450	Normal outdoor levels
<600	Recommended indoor levels
600-1,000	Acceptable indoor levels
1,000-2,500	People may be able to smell the CO ₂ . Stiffness and drowsiness
>2,500	Adverse health effects expected

It's common practice to base minimum fresh airflow rates on either the expected level of occupancy or on the floor area. Where building occupancy patterns vary greatly, ventilation equipment may be overused, resulting in excessive energy consumption.

The best way around this is to monitor the CO₂ levels in a space and control the level of fresh air ventilation accordingly.

When considering CO₂ sensors, you first need to define three elements:

- Minimum ventilation flow rates during occupancy. This is decided either by mandatory requirements (for example, a certain number of litres per second per person) or by choosing from suitable design criteria.
- Occupancy patterns.
- CO₂ control or design level. The higher the control level (in ppm), the lower the volume of fresh air supplied to the building. Similarly, the lower the control level, the greater the volume of fresh air supplied to the building.

CO₂ controls are made up of:

- a sensor that monitors the CO₂ levels.
- a control element fitted to the air handling unit that converts the signal from the sensor into an output, such as increased fan speed or modulation of a damper.

You can fit CO₂ sensors and control equipment to almost any existing ventilation system, but the sensor can only control ventilation equipment within its boundaries, for example:

- A single speed fan will only be turned on or off when CO₂ levels stray outside predetermined set-points. There needs to be some leeway under and over these measures to avoid constant switching on and off.
- A fan fitted with a variable speed motor can be set to continuously reduce or raise its speed to maintain an acceptable level of CO₂ in the building.

With smaller applications – such as a wall-mounted fan controlled via a CO₂ sensor – you need to agree the set-points with the manufacturer during commissioning.

Programming the level of CO₂ that will switch the ventilation system on or off is via a local microprocessor-based controller or through the building management system, if there is one.

CO₂ sensors can either be wall or duct mounted, but wall mounting is the most effective, provided the sensors are in the right places.

Applications

Air quality sensing can be used effectively in office buildings, assembly halls, auditoria lecture theatres, retail buildings, cinemas, restaurants, bars, nightclubs, school and college classrooms and circulation spaces.

It is also possible in some cases in cellular offices storage spaces and toilets, but this technology tends to be less useful in spaces that have a constant, predictable occupancy throughout the day. Air quality sensors can still be used, but they need to be controlled more tightly. There will be lower CO₂ levels used to control the ventilation plant and smaller margins between on/off levels, potentially resulting in a less efficient system.

As a guide, demand controlled ventilation based on CO₂ sensing is most effective in buildings with one or more of the following criteria:

- Occupancy fluctuates over a 24-hour period or is unpredictable.
- There is low occupancy compared to the design occupancy.
- Warm, humid climates.
- Heating, cooling and dehumidifying air accounts for a large proportion of the energy used.
- The outside air supply can be adjusted automatically.
- Ventilation systems have been, or can be, upgraded to electronic or digital controls.
- CO₂ from human respiration is the only or main pollutant.
- There are no high levels of contaminants, such as in laboratories.
- Indoor air quality tends to be poor because of over- or under-ventilation.

Specification checklist

Considerations	Comments
Most appropriate location for sensors.	Sensors should be located where they provide a true reading of the area they serve. Ideally at head height in an area with human activity.
Hard-wired or wireless communication?	The maximum range of wireless communication is around 30m.
CO ₂ control parameters.	May differ depending on occupants' preference.
Do you need to interface or communicate with other controllers – a building management system, for example?	
Can existing ventilation plant accept electronic signals?	Ventilation plant, particularly older equipment, may need to be upgraded.

Commissioning checklist

Actual control settings depend on individual applications, but as a general rule:

- the delay switching time should not be less than 10 minutes to avoid excessive switching on and off of ventilation plant
- ensure sensors are calibrated by the manufacturer or a specialist
- ensure dampers modulate as they should by inspecting them when sensors are being tested
- demonstrate the system and train users
- check sensors by reducing or raising CO₂ levels locally, ensuring that the ventilation plants switches on and off. You will need specialist equipment for this.

Common problems

To ensure the system gets the best balance of air quality and energy saving, check the following.

- Sensors should be placed correctly – ideally wall-mounted at around head height in an area with human activity.
- Sensors can stray from their original settings over time. Calibrate them again when you carry out annual maintenance of ventilation plant.
- Fine-tune the CO₂ set-point by trial and error during the first months of installation to get minimum ventilation rates without making occupants uncomfortable.

Finding a supplier

CO₂ sensors are a relatively simple technology, but it pays to have them fitted by a reputable manufacturer or contractor. You may already have a contractor. If not, try contacting a recognised trade association, such as:

The Heating and Ventilating Contractors' Association (HVCA)
020 7313 4900
www.hvca.org.uk