You get what you measure – VOC regulation

WISE

How do we regulate the ventilation to maintain a pleasant and healthy indoor climate?

Swegon

Has the oxygen really been used up?

You'll have heard people say that a room has "stale air" or that the "oxygen has been used up", but what do they actually mean by that?
And how do we regulate the ventilation to maintain a pleasant and healthy indoor climate?

Most people spend more than 20 hours a day indoors. During this period, a person on average drinks around 3 l of water and eats 1-2 kg of food. A great deal of focus is placed on what we eat, while at the same time the fact that each individual breathes in 15 kg air/day does not interest as many.

The one factor that people tend to be most affected by when it comes to indoor climate is the ambient temperature, and comfort problems are actually just down to the temperature. But even when the temperature is ideal, there will still be other factors affecting how we perceive the comfort level in the short term, and how our health is affected in the long term.

The air around us consists of just under 80% nitrogen and about 20% oxygen, so any claim that the "oxygen is used up" is not really based on fact. Of more interest, is the fact that a small percentage of air is made up of carbon dioxide and some other gases.

As an indicator of the quality of the indoor climate, the CO_2 content is typically used as the reference value. This metric tends to be used in regulatory requirements for workplace design, which stipulate a carbon dioxide content of fewer than 1,000 ppm (parts per million).

However, what are we actually detecting by measuring CO_2, and, more to the point, what are we missing?

In a regulatory context, the CO_2 value is a metric that is easy enough to convey and measure, and offers an indication of how many people have been present in a given space, and above all indirectly points to other unwanted substances in air that arise from human occupancy, and need to be evacuated from the room by ventilation. A CO_2 content of 1,000 ppm or above adversely affects our cognitive performance, making it difficult to absorb information and make strategic decisions, for example. That said, this level in no way poses a threat to human health.

Adjust the air quality to what we ought to measure or what we habitually measure?

An alternative metric for air quality is the content of volatile organic compounds (VOCs). This is actually a collective term for thousands of compounds that occur in our surroundings.

A typical VOC sensor in a ventilation system detects substances naturally emitted by humans such as acetone in our breath, and methane from digestive processes. This means that the VOC levels fluctuate in step with the CO_2 levels, and means that both metrics can be used in matching a ventilation system's air replacement rate to the occupancy rate in the premises.

One key difference, however, is that a VOC sensor also detects a large number of other undesirable compounds emitted by inanimate objects such as building components, like formaldehyde from paint, alcohols and aldehydes from adhesives and solvents, along with benzene and styrene emitted by photocopiers and computers.

By adjusting the indoor climate based on the content of VOC, the ventilation system can thus be turned up when the occupancy rate in a given interior increases, in exactly the same way as a CO_2-regulating system, but it can also detect substances emitted when premises are cleaned, walls are redecorated or a new sofa is installed. These substances will not be detected by a CO_2 sensor, which means that a CO_2 regulated ventilation system will not be activated to remove the contaminants. A ventilation system that reacts to VOCs, will be activated rapidly and air the premises.

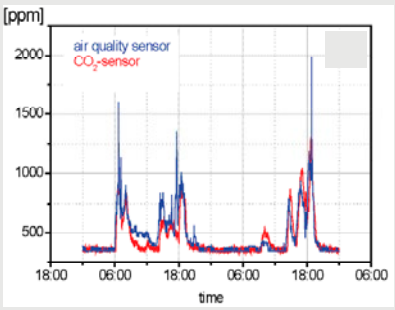

Diagram - Fitness Centre.
Measurement with VOC sensor and CO_2 sensor correspond well.

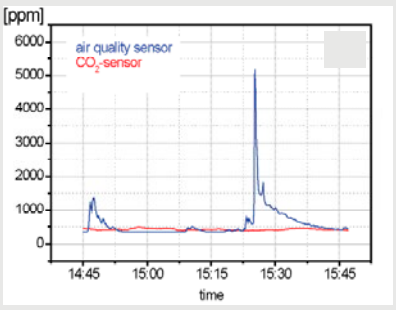

Diagram - Bathroom.
Unlike the CO_2 sensor, the VOC sensor also reacts to odour and perfume.

Why has VOC not replaced CO_2 as the metric of air quality?

One reason is that the VOC level is not measured in terms of absolute ppm values in the same way as CO_2 and that makes it more difficult to use for the threshold value.

The VOC sensor detects thousands of compounds, and instead of setting the threshold value for all of these, the VOC sensor is continually calibrated in order to differentiate between the background value and any actual change in the norm, meaning an influx of airborne contaminants. In other words, it is not as easy to set an absolute maximum permissible value for VOCs. In a modern system based on demand-controlled ventilation, this is not a problem because the VOC level is simply converted into the CO_2 equivalent value.

That begs the question of whether we adjust the air quality to what we ought to measure or what we habitually measure? If the aim is to guarantee a healthy indoor climate, then the VOC level is going to be the ideal metric!

Sources:
Allen, MacNaughton, Satish, Santanam, Vallarino & Spengler, Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments, Environmental Health Perspectives, National Institute of Environmental Health Sciences, USA (https://ehp.niehs.nih.gov/doi/pdf/10.1289/ehp.1510037).
Ekberg, Luftkvalitet, pp 274-275, from Luft, Swegon Air Academy.
Harper, Assessment of the major hazard potential of carbon dioxide (CO_2), Health and Safety Executive (HSE), UK (http://www.hse.gov.uk/carboncapture/assets/docs/major-hazard-potential-carbon-dioxide.pdf).
Herold, Air quality modules for demand controlled ventilation, Applied Sensor.

VOC regulation in Swegon's WISE-system

VOC regulation is used in ventilation systems where the aim is to regulate the air flow according to the content of emission/contaminants in the room air.

Detection of emissions and contaminants

The sensor used to measure VOC in the WISE system detects a large quantity of substances associated to poor air quality, such as alcohol, aldehydes, ketones, amines, organic acids, and more. There are some 5000 - 10,000 different volatile organic compounds (odours, etc) of which the VOC sensor detects virtually all or at least typical representatives within each group, as well as typical gases such as carbon monoxide and hydrogen (both from combustion) as well as methane gas. The table below provides an overview of the main contaminants, groups and sources.

Indoor air Source of pollutants	**Source of emissions**	**Typical substances**	
		VOC*	**Miscellaneous**
People	Breathing	Acetone, Ethanol, Isoprene	
		CO_2 Humidity	
	Skin's breathing and perspiration	Nonanal, Decanal, a-pines	
		Humidity	
	Body gases	Methane gas, Hydrogen gas	
	Cosmetics	Lemon oil, Eucalyptus	
	Household products	Alcohols, Esters, Lemon oil	
		Unburnt hydrocarbons	
	Combustion (engines, appliances, tobacco smoke)	CO	
		CO_2	
		Humidity	
Building materials Furniture Office equipment Consumer products	Paint Glue, solvent Mats	Formaldehyde, Alkane, Alcohols, Aldehydes, Ketones, Siloxanes	
	Plastic	Toluene, Xylene, Decane	
	Printer, copiers, computers	Benzene, Styrene, Phenol	

*) VOC = Volatile Organic Compounds, i.e. volatile organic pollutants.

This is how the air flow is regulated

The VOC levels are not measured in terms of absolute ppm values in the same way as CO_2 and that makes it more difficult to use for the absolute threshold value. The VOC sensor detects thousands of compounds, and instead of setting the threshold value for all of these, the VOC sensor is continually calibrated in order to differentiate between the background value and any actual change in the norm, meaning an influx of airborne contaminants. Control of the air flow is the total amount of emissions and contaminants. Thus it is not possible to discern specific VOC or substances and only control these.

The VOC sensor has an integrated operating compensation and prognosis algorithm that continuously calibrates itself, based on the recognition of models and advanced signal analysis. It calibrates based on an algorithm with recognition of models and converts the VOC level to CO_2 equivalent PPM values. A constant low level of volatile organic substances (also known as "background") can be perceived as a base level and is adopted by the sensor. Nevertheless, you need not worry that the sensor has gradually adopted a high base value at high levels of contaminants, as it will always gradually adjust to lower values when the contaminants are vented out.

As the sensor is self-calibrating in this way, it is not necessary to calibrate the sensor.

Components for VOC regulation

The VOC content can be measured either in the room using the room accessory WISE IAQ VOC or WISE IAQ Multi, which measures both VOC and CO_2, or in climate products. Comfort module WISE Parasol Zenith or extract air damper WISE Damper can be equipped with integrated VOC sensor WISE SMA (Sensor Module Advanced) which measures the VOC content.

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