CO_2 measured values below 400 ppm – Error or reality ?

Indoor air quality has a direct impact on health, productivity and comfort. A key parameter for assessing air quality is the CO_2 concentration. People continuously release CO_2 into the environment when they breathe. An increase in concentration usually indicates stale air. Ventilation lowers the value again, illustrating the connection between CO_2 and air quality.

Outdoor air is often used as a reference for "fresh air". According to NOAA, the average CO_2 concentration in global outdoor air is currently around 425 ppm. In practice, however, this reference value is not the only one used: Many users consider 400 ppm to be a typical guideline value or lower measurement limit. If a device displays less than 400 ppm, a measurement error is often suspected. This conclusion does not necessarily have to be correct.

Measured values of less than 400 ppm can actually occur indoors. Such values are not necessarily a sign of a defective sensor, but can be explained physically.

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CO_2 binding to concrete

- CO_2 can bind to the surfaces of concrete buildings. Concrete contains calcium-based components that react with CO_2. This is known as carbonation. In this process, CO_2 is absorbed from the indoor air and chemically bound.

- As a result, concrete acts as a CO_2 reservoir in a room. Although the absorption rate is low, it can be measured in rooms with little or no use and limited air exchange. The decisive factor here is not necessarily a large quantity of concrete, but rather the combination of the available concrete surface area, room usage, and ventilation situation.

- Such conditions occur, for example, in new buildings prior to the commissioning of ventilation systems, or in rooms that remain unoccupied for a prolonged period and are not ventilated or purified. In these cases, CO_2 values of well below 400 ppm can be measured.

- With increasing human use as a source of CO_2 and higher air exchange rates, the effect of carbonation is masked and can no longer be measured.

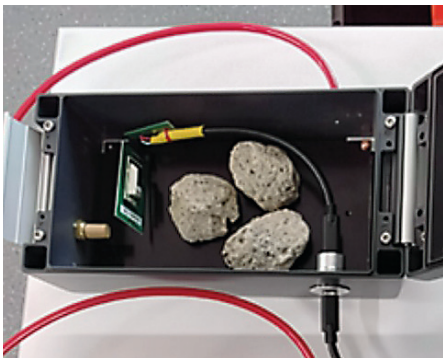
Experimental proof

An experiment was carried out to verify this connection. Two identical boxes were each equipped with a CO_2 sensor.

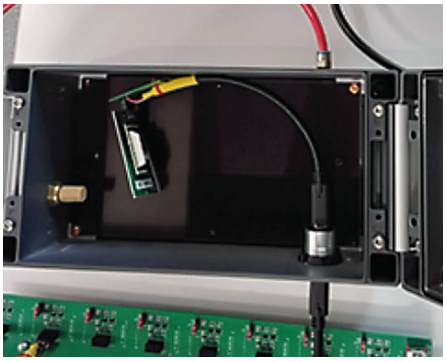
Experimental setup

- **Box A** (with concrete): Airtight box containing pieces of concrete and a CO_2 sensor
- **Box B** (reference): Airtight box without pieces of concrete, also equipped with a CO_2 sensor

Both boxes were initially exposed to the same indoor air with a CO_2 concentration of approx. 600 ppm, after which they were simultaneously sealed in an airtight manner. The CO_2 content was recorded over a period of 48 hours.



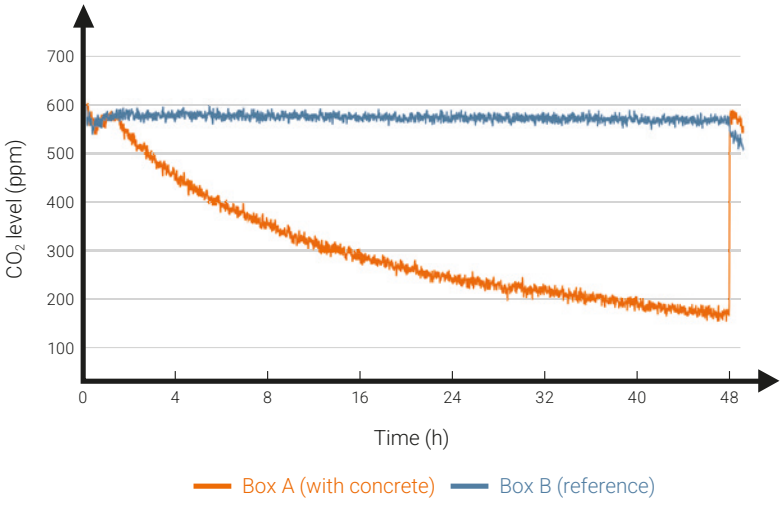
Box A (with concrete)



Box B (reference)

Result

- In **Box A**, the CO_2 concentration fell continuously and reached values well below 200 ppm.
- In **Box B**, the CO_2 concentration remained almost constant at around 600 ppm.

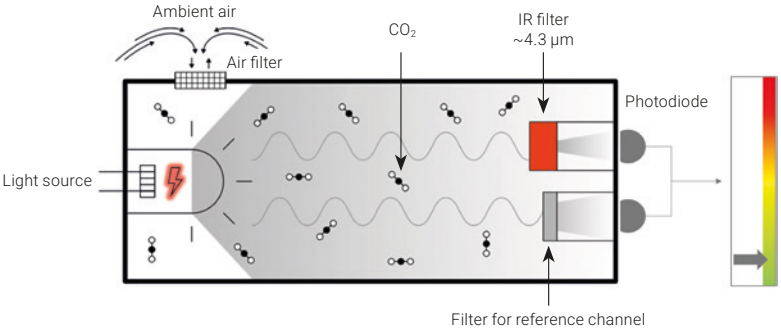


The experiment clearly shows that concrete binds CO_2 and can therefore significantly reduce the measured CO_2 concentration in the indoor air below the outdoor air level of approx. 425 ppm.

In terms of scale, the experimental setup can be compared to a room measuring 10 m × 10 m × 3 m, in which only a single wall is made of concrete. Even such a small concrete surface can be enough to have a measurable effect on the CO_2 value of the indoor air, especially if the room is not in use.

Why do some sensors display values below 400 ppm and others do not?

The duct and room units from Belimo are equipped with factory-calibrated NDIR sensors with dual-beam technology. The measurement is performed using infrared and two light beams: One beam measures the CO_2 concentration, the second serves as a stable reference. This continuously compensates for ageing and drift, ensuring that the factory calibration is maintained over a long period of time.



This is particularly advantageous in buildings with permanent occupancy, such as retirement and nursing homes, hospitals, prisons or airports. In such applications, the CO_2 values of the outdoor air level are often not reached. Dual-beam sensors nevertheless remain correctly calibrated and display reliable measured values even when values occasionally fall below 400 ppm.

In contrast, simpler CO_2 sensors are often not permanently stable and are subject to greater drift. To compensate, an automatic baseline correction (ABC logic) is often used. It is assumed that the sensor is regularly exposed to fresh outdoor air within a defined period of time and that the lowest measured value corresponds to around 400 ppm.

However, if real CO_2 concentrations of less than 400 ppm occur, for example 300 ppm, this assumption can no longer be fulfilled. The sensor incorrectly interprets this value as drift and adjusts the measured value upwards. The result is seemingly plausible, but actually excessively high CO_2 readings. This gives the user a false sense regarding the actual air quality.

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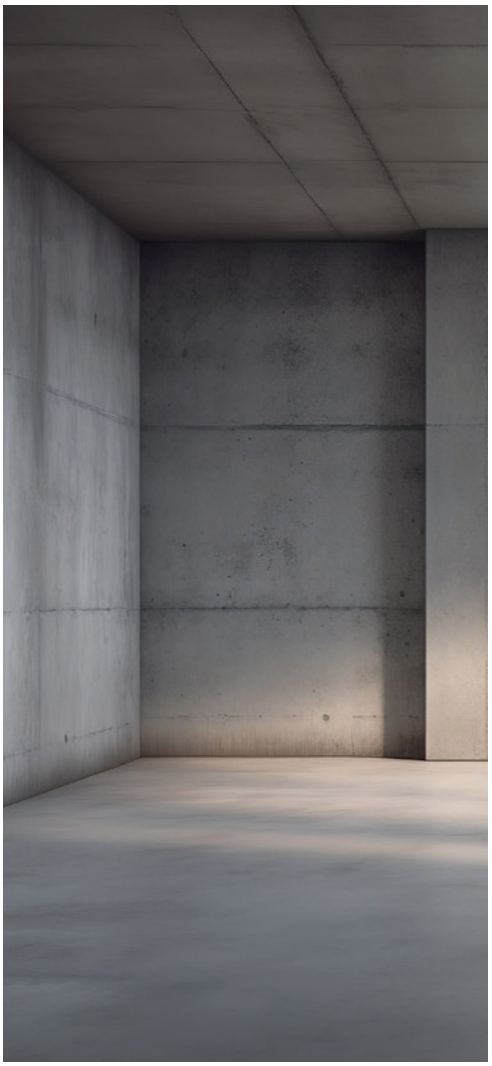
The ABC logic therefore only works reliably if regular flushing with outdoor air takes place and the lowest CO_2 value actually corresponds to the outdoor air level.

Conclusion

CO_2 measured values below 400 ppm are possible and do not necessarily indicate a defective sensor. In rooms with a certain amount of concrete, CO_2 can be bound through carbonation. Depending on usage and ventilation of the room, even small concrete surfaces can cause the CO_2 concentration to temporarily fall below the level of the outdoor air.

Duct and room units from Belimo with dual-beam technology detect these situations correctly. CO_2 sensors with ABC logic, on the other hand, correct their measured values to an assumed reference value of around 400 ppm. Real values below this range are usually adjusted upwards and no longer correspond to the actual indoor air concentration.

With increasing use, higher air exchange rates and progressive saturation of the surfaces, the effect of carbonation decreases. The CO_2 values stabilise at a level that is comprehensible to the occupant. Indoor conditions similar to outdoor air typically only occur if rooms are unoccupied for a prolonged period and are actively ventilated or purified at the same time.



All inclusive

Belimo is the global market leader in the development, production, and sales of field devices for the energy-efficient control of heating, ventilation and air-conditioning systems. The focus of our core business is on damper actuators, control valves, sensors and meters.

Always focusing on customer value, we deliver more than only products. We offer you the complete product range for the regulation and control of HVAC systems from a single source. At the same time, we rely on tested Swiss quality with a five-year warranty. Our worldwide representatives in over 80 countries guarantee short delivery times and comprehensive support through the entire product life. Belimo does indeed include everything.

The "small" Belimo devices have a big impact on comfort, energy efficiency, safety, installation and maintenance.

In short: Small devices, big impact.

- 5-year warranty
- On site around the globe
- Complete product range
- Tested quality
- Short delivery times
- Comprehensive support

EN – 03.2026 – Subject to technical modifications

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