ASHRAE's New Position Document on Indoor Carbon Dioxide

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Indoor CO_2 concentrations are often discussed in the context of ventilation and IAQ (indoor air quality), including indoor CO_2 as an IAQ metric, ventilation rate estimation using CO_2 as a tracer gas, control of outdoor air ventilation, and impacts of CO_2 on building occupants. More recently CO_2 has been discussed in the context of airborne infectious disease transmission. However, many applications of indoor CO_2 do not reflect a sound technical understanding of the relationship between indoor CO_2 concentrations, ventilation and IAQ, and some applications have actually been technically flawed. In response to these concerns, ASHRAE has recently issued a Position Document (https://tinyurl.com/2p97a7zw) on the role of indoor CO_2 in the context of building ventilation and IAQ. This column presents the positions and recommendations in the document, which also contains a thorough discussion of the supporting background and extensive references for the interested reader.

The position document addresses the use of CO_2 as a metric of IAQ and ventilation, impacts of CO_2 on building occupants, indoor CO_2 concentration measurement, use of CO_2 to control outdoor air intake rates, and the relationship of indoor CO_2 to airborne infectious disease transmission. It also includes the motivations for developing the document and contains a background section that discusses the history of indoor CO_2 concentrations in the context of ventilation and IAQ, health and cognitive impacts of exposure to CO_2, existing standards and regulations for indoor CO_2 concentrations, CO_2 as an indicator of IAQ and ventilation, use of CO_2 as a tracer gas for estimating ventilation rates, increases in outdoor CO_2 concentrations, air cleaning directed at CO_2 removal alone, and CO_2 as an indicator of the risk of airborne disease transmission.

Indoor CO_2 has been discussed in the context of building ventilation and IAQ for literally centuries. More recent work has focused on two areas: how CO_2 concentrations relate to occupant perception of human bioeffluents and other aspects of IAQ, and the use of CO_2 to evaluate outdoor air ventilation rates. While a great deal of research on these topics has been conducted over the past several decades, misinterpretation of CO_2 as an indicator of IAQ and ventilation still occurs in the HVAC industry, IAQ research community, and the public. There have been many efforts to address this confusion in standards and guidance documents, technical publications, conference presentations and workshops, but significant misunderstanding remains and motivated the development of this position document.

In addition to the need to clarify the relationship of indoor CO_2 to IAQ and ventilation, other motivations for this position document include recent research results on the impacts of CO_2 on human cognitive performance at commonly observed indoor concentrations that were previously thought not to be of concern. Other recent studies have examined physiological impacts at these lower concentrations, distinct from, though perhaps related to, cognitive and performance effects.

Given trends of increasing outdoor CO_2 concentrations, additional concerns have been expressed regarding these potential health and performance impacts of CO_2 concentrations in non-industrial indoor environments. Moreover, a variety of organizations and government bodies have issued standards and regulations for indoor CO_2 concentrations in non-industrial workplaces, and CO_2 sensors have become less expensive and more widely deployed.

Concerns have long existed regarding the accuracy of indoor CO_2 concentration measurements, and they are increasing with the availability and more widespread application of CO_2 sensors. These concerns also include sensor locations that reflect air distribution within a space and occupant location. Indoor CO_2 monitoring has also been promoted as a ventilation indicator in the context of managing the risks of airborne disease transmission. Finally, most of these applications of indoor CO_2 require values for the rate at which building occupants generate CO_2 and other inputs, and the uncertainty of these values has not been well characterized.

The Position Document states the following positions:

- Indoor CO_2 concentrations do not provide an overall indication of IAQ, but they can be a useful tool in IAQ assessments if users understand the limits in these applications.
- Existing evidence for impacts of CO_2 on health, well-being, learning outcomes and work performance at commonly observed indoor concentrations is inconsistent, and therefore does not currently justify changes to ventilation and IAQ standards, regulations, and guidelines.
- The use of indoor CO_2 measurements to assess and control the risk of airborne disease transmission must account for the definition of acceptable risk, the type of space and its occupancy, and differences in CO_2 and infectious aerosol emissions and their subsequent fate and transport.
- Differences between indoor and outdoor CO_2 concentrations can be used to evaluate ventilation rates and air distribution using established tracer gas measurement methods, but accurate results require the validity of several assumptions and accurate input values.
- Sensor accuracy, location and calibration are all critical for drawing meaningful inferences from measured indoor CO_2 concentrations.
- Air cleaning technologies that remove only CO_2 will not necessarily improve overall IAQ and can interfere with systems using CO_2 for ventilation control or IAQ monitoring.

The Position Document recommends research in the following areas:

- Indoor CO_2 exposure as a modifier of human responses to other environmental factors such as thermal comfort and other airborne contaminants
- The development of IAQ metrics that cover the wide range of indoor contaminants and sources
- Health and performance impacts of indoor CO_2 in concentration ranges typical of nonindustrial indoor environments in both laboratory and field settings covering a diverse range of subjects, including variations in age, gender, and health status
- Physiological impacts of elevated CO_2 concentrations, such as changes in blood

chemistry and respiration, including those associated with increasing outdoor CO_2 concentrations
- The relationship between indoor CO_2 concentrations and the risks of airborne infectious disease transmission
- Indoor CO_2 concentration measurement, including sensor performance and sensor locations for different applications and the performance and application of low-cost CO_2 sensors
- The use of occupant-generated CO_2 as a tracer gas to estimate building ventilation rates, including approaches that capture transient effects and account for multiple-space ventilation systems and different air distribution approaches
- Strategies for demand-controlled ventilation (DCV) using CO_2 and other indicators of occupancy that overcome limitations of current approaches and control contaminants that are not linked to occupancy
- Indoor CO_2 concentrations, ventilation rates, and occupancy in different building types in different countries to establish benchmark data and better understand the impacts of new building and system designs, tighter construction, advanced operation and control strategies, and other changes in the building stock

The Position Document also recommends the pursuit of several activities:
- Development of guidance and standards on indoor CO_2 concentration measurement and sensor selection, especially for DCV applications
- Development of educational programs, conference sessions and workshops, and guidance documents to help practitioners and researchers understand the application of indoor CO_2 concentrations as an indicator of ventilation and IAQ
- Development of guidance on HVAC equipment and controls using CO_2 monitoring
- Development of guidance on the use of CO_2 as a tracer gas for measuring building ventilation rates and air distribution

This new ASHRAE position document helps to clarify the role of indoor CO_2 in the context of ventilation and IAQ and should be useful to practitioners, researchers and policymakers. As the recommendations for additional research and guidance are implemented, the information generated will further improve the application of indoor CO_2 concentrations in improving IAQ.