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Quit Blaming ASHRAE Standard 62.1 for 1000 ppm CO_2

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1 Introduction

Indoor concentrations of carbon dioxide (CO_2) have been widely promoted as metrics of indoor air quality (IAQ) and ventilation, in many cases without a sound explanation of what they are intended to characterize or an adequate discussion of the specific application and any limitations. Many practitioners and researchers use 1800 mg/m^3 (roughly 1000 ppm$_v$) as a criteria for defining good IAQ and cite ASHRAE Standard 62.1 (ASHRAE, 2019) as the source of this value. Standard 62.1 has not contained an indoor CO_2 limit for almost 30 years, and no current ASHRAE standard contains an indoor CO_2 limit. The CO_2 limit was removed from Standard 62.1 based on the confusion that it caused and the fact that it is not a good indicator of ventilation or IAQ. Numerous papers, presentations and workshops have attempted to clarify the significance of indoor CO_2 concentrations and even advocated that they not be used as IAQ or ventilation metrics. However, these efforts have not ended the confusion, and the attribution of a 1800 mg/m^3 limit to Standard 62.1 continues. This paper describes what Standard 62.1 says about CO_2 now, what it has said in the past, explains the basis for the 1800 mg/m^3 value, and stresses that the use of a CO_2 reference value to characterize ventilation rates must consider the building type and its occupancy.

2 Historical Background

Indoor CO_2 concentrations have been discussed in the context of IAQ and ventilation for centuries. Those discussions have considered the importance of CO_2 in relation to bioeffluent perception, its application as an IAQ metric, CO_2 as a contaminant in and of itself, and its use as a tracer gas to estimate outdoor air ventilation rates. Despite many attempts to clarify the application of CO_2 to IAQ and ventilation (Persily, 1997; ASTM, 2018), much confusion has existed over the past decades and continues today. For example, there are numerous statements to the effect that a building has good IAQ because it complies with the 1000 ppm$_v$ CO_2 limit in ASHRAE Standard 62.1. This statement has multiple problems: we are not able to define good IAQ; CO_2 is not a critically important contaminant in indoor air; and, there is no 1000 ppm$_v$ limit in the standard.

ASHRAE Standard 62-1981 introduced the Indoor Air Quality Procedure, an alternative, performance-based design approach in which the ventilation system is designed to achieve target levels of indoor contaminants. This approach is in contrast to the prescriptive Ventilation Rate Procedure, in which the design must meet specific outdoor air ventilation requirements that are specific to a type of space. As part of the IAQ Procedure, the 1981 standard included a list of 20 compounds or classes of compounds with concentration limits for five of them: CO_2, chlordane, formaldehyde, ozone and radon. All of the limits were linked to a U.S. or other national government reference with the exception of CO_2. The CO_2 limit of 4500 mg/m^3 is discussed in an appendix to the 1981 standard, which noted (without reference) that 0.5 % CO_2 is a good limit based on concerns about headaches and loss of judgment. A safety factor of two is then used to account for variations in individual activity, diet and health, leading to the stated limit of 0.25 % (about 4500 mg/m^3). The 1989 standard contained concentration limits for four contaminants (CO_2, chlordane,

ozone and radon) for use with the IAQ Procedure. The CO_2 limit in the 1989 standard was 1800 mg/m^3 (roughly 1000 ppm_v), 60 % lower than the value in the 1981 standard, but no explanation was provided for this reduction.

3 More Recent Versions of Standard 62.1

Subsequent versions of Standard 62 in 1999 and 2001 retained the contaminant limits that were in the 1989 standard, although CO_2 was removed from the table in 1999. That table was removed entirely from the 2004 version of the standard, with all discussions of contaminant limits contained in informative appendices.

The confusion regarding CO_2 in Standard 62.1 is likely associated with an informative appendix (not officially part of the standard) that was added in 1989. That appendix explained the connection between per person outdoor air ventilation rates and steady-state levels of CO_2. That discussion notes that for specified values of CO_2 generation by a person and of the outdoor CO_2 concentration, a ventilation rate of 7.5 L/s (15 cfm) per person will lead to a steady-state CO_2 concentration of 1000 ppm_v. That discussion was apparently interpreted by some as justifying the 1000 ppm_v limit in the body of the standard under the IAQ Procedure, but that is not what the standard stated.

As noted above, the 1000 ppm_v limit was removed from the standard in 1999, and the appendix was modified to better explain the connection between CO_2 concentrations and bioeffluent perception. The modified appendix noted that 7.5 L/s of outdoor air will dilute bioeffluent odors such that about 80 % of unadapted persons (visitors) are satisfied in their perception of those odors. It again noted that for assumed values of CO_2 generation, 7.5 L/s will lead to a steady-state CO_2 concentration that is 700 ppm_v above outdoors. That explanation, which is not a CO_2 concentration limit, remained in the standard through 2016 and was removed from the 2019 standard.

It is important to understand that the relationship of 7.5 L/s and 1000 ppm_v is only relevant to spaces for which 7.5 L/s is the outdoor air ventilation requirement. While office spaces are required to provide about 7.5 L/s per person (depending on occupant density), other spaces have ventilation requirements ranging from less than 3 L/s to 12 L/s or more. In those cases, the steady-state CO_2 concentration will be quite different from 1000 ppm_v, ranging from roughly 700 ppm_v to 5000 ppm_v, again depending on the occupancy density. Therefore, identifying relevant CO_2 concentrations that correspond to ventilation rate requirements must consider the building type and its occupancy.

4 Conclusions

Despite the fact that ASHRAE Standard 62.1 has not contained an indoor CO_2 concentration limit for the past 30 years, there are many instances in which practitioners and researchers make claims that a building has good IAQ because it complies with the 1000 ppm_v CO_2 limit in the standard. More recent versions of the standard do not include any statement implying that 1000 ppm_v is a guideline or target value. While the direct impacts of indoor CO_2 concentrations on human health, comfort and performance are of interest, and new research is being conducted to examine those impacts, there is not yet sufficient justification to change existing ventilation standards (Fisk et al., 2019).

5 References

ASHRAE. 2019. ANSI/ASHRAE Standard 62.1-2019, Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta (USA).

ASTM. 2018. ASTM 6245-2018, Standard Guide for Using Indoor Carbon Dioxide Concentrations to Evaluate Indoor Air Quality and Ventilation. ASTM International, West Conshohocken (USA).

Fisk W., Wargocki P. and Zhang X. 2019. Do Indoor CO_2 Levels Directly Affect Perceived Air Quality, Health, or Work Performance. ASHRAE Journal, 61 (9): 70-77.

Persily A. 1997. Evaluating Building IAQ and Ventilation with Indoor Carbon Dioxide ASHRAE Transactions, 103(2): 193-204.

Persily A. 2015. Challenges in developing ventilation and indoor air quality standards: The story of ASHRAE Standard 62. Building and Environment, 91: 61-69.