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The Role of Carbon Dioxide in Ventilation and IAQ Evaluation: 40 years of AIVC

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SUMMARY
The purpose of this summary is to review Air Infiltration and Ventilation Centre activities, as reflected in its publications, related to indoor carbon dioxide over the 40 years that have transpired since its creation. These activities, like most applications of indoor CO_2 to the fields of ventilation and indoor air quality, have focused on the following: control of outdoor ventilation rates, i.e., demand control ventilation; use as a tracer gas to measure outdoor air change rates; providing an indicator or metric of IAQ; and, directly impacting human health, comfort and performance. More recent work on CO_2 generation rates from building occupants and CO_2 concentrations in standards and building regulations is also covered. This summary was generated by searching on Air Infiltration and Ventilation Centre publications, though the findings also reflect the evolving application and understanding of indoor CO_2 in the broader literature.

KEYWORDS: carbon dioxide; indoor air quality; metrics; ventilation

GENERAL DISCUSSIONS OF INDOOR CO_2

One of the earliest Air Infiltration and Ventilation Centre (AIVC) publications on the application of indoor CO_2 is a short article covering a range of topics, including tracer gas applications, indoor air quality (IAQ) evaluation, and CO_2 as an indicator of occupancy (Liddament, 1996). Another short paper was published more recently, which focused on CO_2 as an IAQ indicator and for ventilation control (de Gids and Wouters, 2010). No other general reports or publications on CO_2 have been issued by the AIVC over its 40 years. The application of CO_2 has been covered mostly by individual conference papers on the topics covered below. For each of the topics, a table of references is provided at the end of this summary. These tables are not exhaustive but provide a sense of the issues covered for each topic.

DEMAND CONTROL VENTILATION

Indoor CO_2 has been discussed as a control parameter for outdoor air ventilation for decades, with the goal being to provide sufficient ventilation for the occupants in a space. Ventilating for the actual occupancy rather than a maximum design value provides an opportunity to reduce energy used for space heating and cooling, as well as assuring that the ventilation is sufficient to meet the needs of the occupants. In 2001 the AIVC generated a literature list (LL) that identified about 50 publications on the topic of CO_2 demand control ventilation, many of them not published by the AIVC itself. Additional work on the topic has continued in subsequent publications on sensor performance, energy and IAQ impacts, case studies in a variety of building types and other subtopics as noted in the table below.

CO_2 AS A TRACER GAS

Carbon dioxide has long been recognized as a useful tracer gas for studying building ventilation and airflow given its low reactivity and toxicity, relative ease of measurement and, in some

applications, building occupants serving as a convenient tracer gas source. CO_2 was identified as a potential tracer gas in an early AIC publication (Liddament and Thompson, 1983). Since that time, CO_2 has been used as a tracer gas in many studies, with several noted below.

IAQ ASSESSMENT

Indoor CO_2 concentrations have long been used as part of IAQ assessments with the oldest reference listed in the table below dating back to 1985. Some of these assessments measure CO_2 concentrations as one of many pollutants monitored, though many assessments do not explain the significance of the measured concentrations or compare them to a reference or guideline value. Such measurements are still common as part of IAQ investigations; the explicit consideration of CO_2 concentration metrics is a more recent development and is discussed next.

IAQ METRIC

The AIVC has focused on IAQ metrics in recent years, with the topic being a major theme of its 2016 conference held in conjunction with the ASHRAE IAQ conference series. Only two papers on the topic of CO_2 as an IAQ metric are listed in the table below, but the issue has been discussed in recent AIVC workshops and conference sessions without any papers being published and those discussions are likely to continue.

CO_2 GENERATION RATES

The use of CO_2 as a tracer gas for quantifying building and space ventilation rates requires a value of the rate of CO_2 generation by the building occupants. For many years, default values from ASHRAE and other sources have been used without evaluating their accuracy or the sources on which they were based. Recent publications have developed more well-documented and robust methods for estimating these generations rates, with three AIVC conference papers included in the table below.

STANDARDS AND REGULATIONS

While indoor CO_2 has been considered in ventilation and IAQ studies for decades, most standard or guideline values were only for industrial environments. More recently a number of standards and building regulations have been promulgated with specific indoor CO_2 concentration limits. Several of these are covered by the publications listed in the table below, though other countries and localities appear to also be setting such limits.

CO_2 IMPACTS ON BUILDING OCCUPANTS

Finally, a number of recent studies have taken a new look at how CO_2 impacts building occupants both physically and mentally. Many of these studies have been looking at concentrations that are typical of indoor spaces. However, the studies in the broader literature are not consistent as to the human effects observed. The three studies listed in the table below are just an example of such work that has been presented in recent AIVC conferences.

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