Ventilation Management to Reduce Airborne Transmission Risks *and Improve Indoor Air Quality*

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NASEM Environmental Health Matters Initiative
Indoor Air Management of Airborne Pathogens: Lessons, Practices, and Innovations
18 August 2022

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
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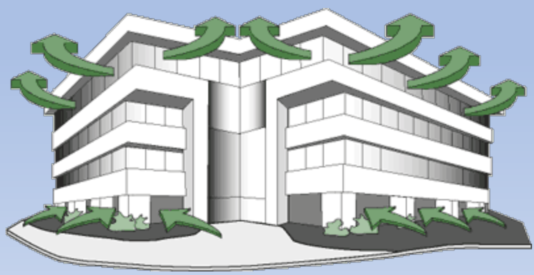


Ventilation Management: What's been recommended

Inspect systems; verify operation per design & standards
Change standards for more air, more filtration, …

MORE: outdoor air, filtration, open windows, humidity

Monitor indoor CO_2
Concentrations below X ppm_v indicate good ventilation/low risk

Improve air distribution for air delivery & aerosol removal

MISC: Longer ventilation operation (e.g., 24/7), Flushing before/after occupancy; Disable demand control ventilation

Buildings and systems vary

USA: >140 million dwellings; 6 million commercial

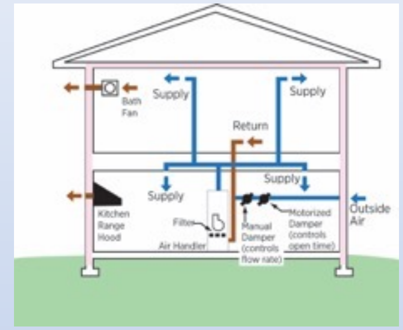



Building systems

Layout, design, control, capacity, occupant activities, operation, maintenance, …




System type & operation impact ventilation management options

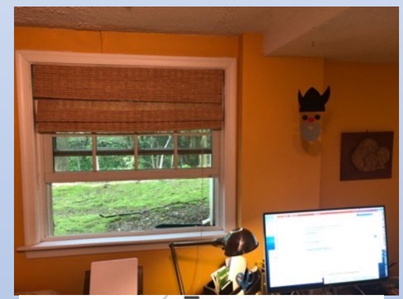


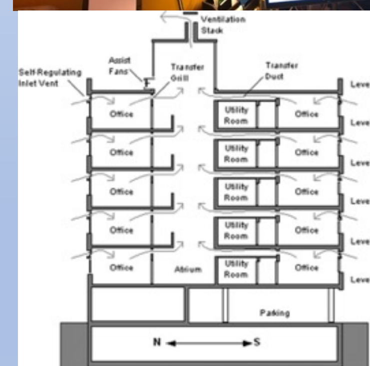
Mechanical ventilation

Outdoor air (OA) intake control?

Capacity for more OA?

Simple system have limited options





Natural ventilation:

Operable windows or engineered system

Ventilated by leakage only, i.e., infiltration

Ventilation assessment: To understand system & options before making changes

Persily. 2021. *Evaluating Ventilation Performance*, *Handbook of Indoor Air Quality*.

System Design

- Documentation exist? Is it current? What standard used?
- Outdoor air intake rate; Recirculation; Local mixing boxes; Filter efficiency; Heat/enthalpy recovery; Operating schedule; Controls

Actual performance

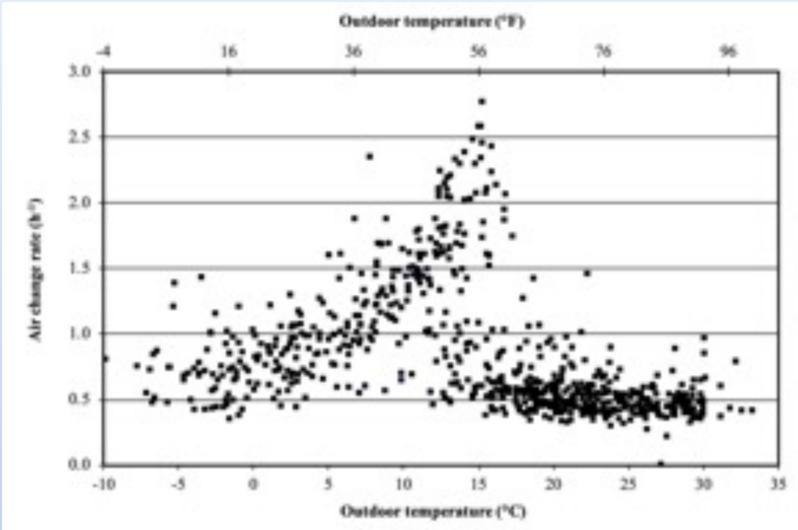
- System status: on/off, mode of operation, …
- System airflows: Supply, outdoor air, exhaust
- Whole building outdoor air change rates
- Pressure differences, air distribution/ventilation effectiveness

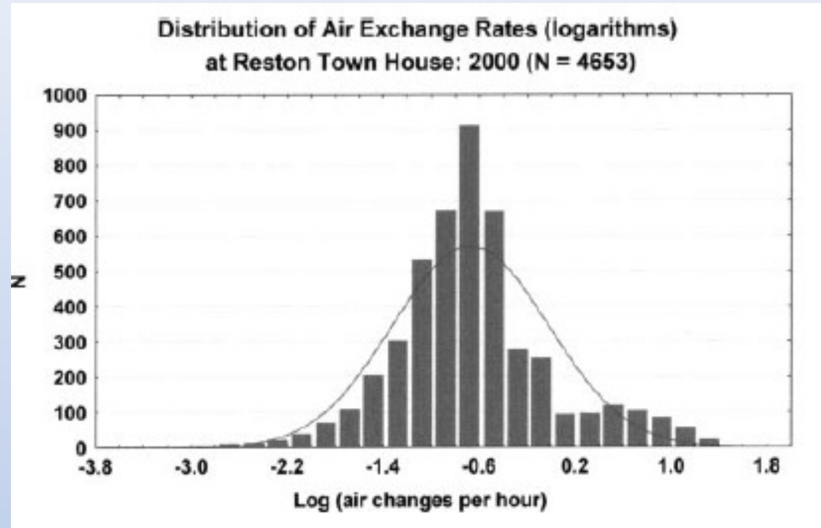
Other important factors

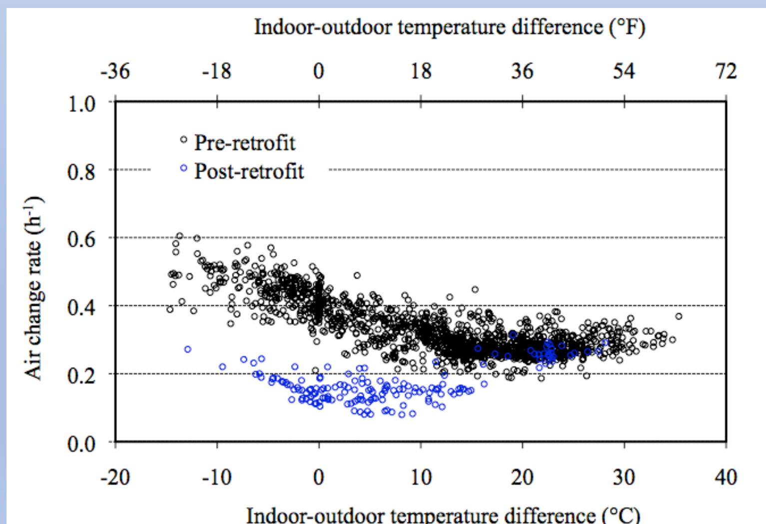
- Condition of system components
- Operations & Maintenance programs

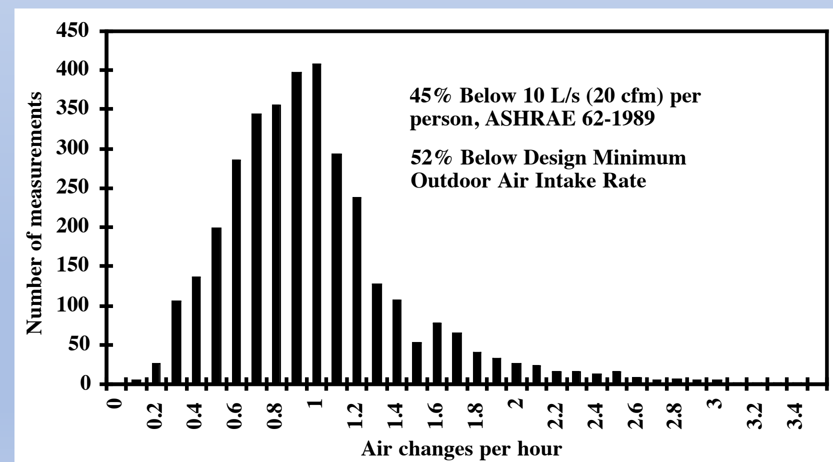
One measurement doesn’t tell you much!

Air change rates vary!









Persily. 2016. *Field measurement of ventilation rates.* Indoor Air. **26(1)**: 97-111.

CO_2 monitoring can be useful

1. Understand technical basis
2. Measure and interpret with care

Courtesy of David Meyer, Shenandoah University

History of confusion and misinterpretation

More measurement & less expensive sensors

Guidance not always clear

2 reasons to monitor CO_2

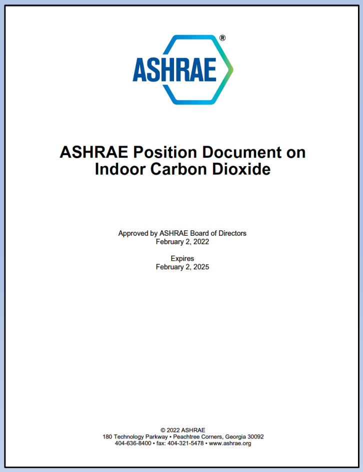
Verify protective ventilation rate

Indicator of transmission risk

Critical to include with concentration data:

building & system design, timing relative to occupancy, sensor location, measurement accuracy, outdoor concentration,

ASHRAE Position Document on Indoor CO_2



ASHRAE Position Document on Indoor Carbon Dioxide

Approved by ASHRAE Board of Directors
February 2, 2022

Expires
February 2, 2025

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CO_2 as a metric of adequate ventilation

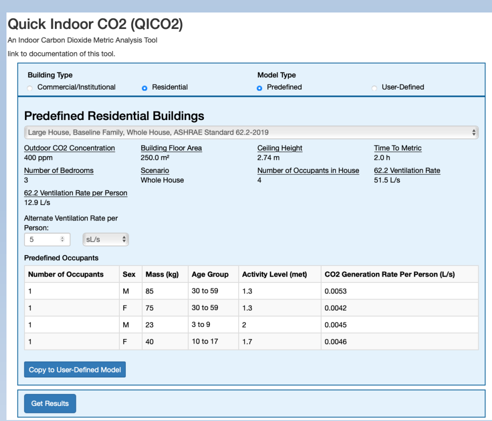
A single value for all spaces doesn't make sense

Must consider timing of occupancy & measurement, occupants, target ventilation rate, …

Recently proposed space-specific CO_2 metric

QICO2: On-Line Calculator

(Search on: NIST CO2 tool)



Quick Indoor CO2 (QICO2)

An Indoor Carbon Dioxide Metric Analysis Tool

link to documentation of this tool.

Building Type: Commercial/Institutional | Residential

Model Type: Predefined | User-Defined

Predefined Residential Buildings

Large House, Baseline Family, Whole House, ASHRAE Standard 62.2-2019

Outdoor CO2 Concentration: 400 ppm
Building Floor Area: 250.0 m²
Ceiling Height: 2.74 m
Time To Metric: 2.0 h
Number of Bedrooms: 3
Scenario: Whole House
Number of Occupants in House: 4
62.2 Ventilation Rate: 51.5 L/s
62.2 Ventilation Rate per Person: 12.9 L/s

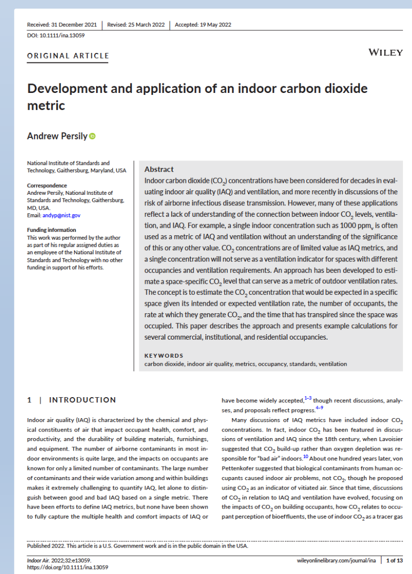
Alternate Ventilation Rate per Person: 5 sL/s

Predefined Occupants

Number of Occupants	Sex	Mass (kg)	Age Group	Activity Level (met)	CO2 Generation Rate Per Person (L/s)
1	M	85	30 to 59	1.3	0.0053
1	F	75	30 to 59	1.3	0.0042
1	M	23	3 to 9	2	0.0045
1	F	40	10 to 17	1.7	0.0046

Copy to User-Defined Model

Get Results



Received: 31 December 2021 | Revised: 25 March 2022 | Accepted: 19 May 2022
DOI: 10.1111/ina.13059

ORIGINAL ARTICLE

WILEY

Development and application of an indoor carbon dioxide metric

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Funding information
This work was performed by the author as part of his regular assigned duties as an employee of the National Institute of Standards and Technology with no other funding in support of his efforts.

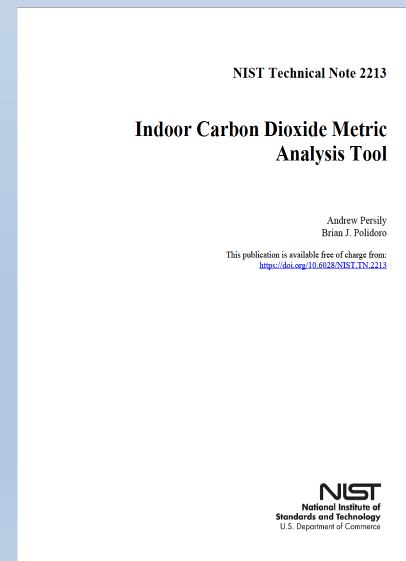
Abstract
Indoor carbon dioxide (CO_2) concentrations have been considered for decades in evaluating indoor air quality (IAQ) and ventilation, and more recently in discussions of the risk of airborne infectious disease transmission. However, many of these applications reflect a lack of understanding of the connection between indoor CO_2 levels, ventilation, and IAQ. For example, a single indoor concentration such as 1000 ppm_v is often used as a metric of IAQ and ventilation without an understanding of the significance of this or any other value. CO_2 concentrations are of limited value as IAQ metrics, and a single concentration will not serve as a ventilation indicator for spaces with different occupancies and ventilation requirements. An approach has been developed to estimate a space-specific CO_2 level that can serve as a metric of outdoor ventilation rates. The concept is to estimate the CO_2 concentration that would be expected in a specific space given its intended or expected ventilation rate, the number of occupants, the rate at which they generate CO_2, and the time that has transpired since the space was occupied. This paper describes the approach and presents example calculations for several commercial, institutional, and residential occupancies.

KEYWORDS
carbon dioxide, indoor air quality, metrics, occupancy, standards, ventilation

1 | INTRODUCTION

Indoor air quality (IAQ) is characterized by the chemical and physical constituents of air that impact occupant health, comfort, and productivity, and the durability of building materials, furnishings, and equipment. The number of airborne contaminants in most indoor environments is quite large, and the impacts on occupants are known for only a limited number of contaminants. The large number of contaminants and their wide variation among and within buildings makes it extremely challenging to quantify IAQ, let alone to distinguish between good and bad IAQ based on a single metric. There have been efforts to define IAQ metrics, but none have been shown to fully capture the multiple health and comfort impacts of IAQ or have become widely accepted,[1-3] though recent discussions, analyses, and proposals reflect progress.[4-9]

Many discussions of IAQ metrics have included indoor CO_2 concentrations. In fact, indoor CO_2 has been featured in discussions of ventilation and IAQ since the 18th century, when Lavoisier suggested that CO_2 build-up rather than oxygen depletion was responsible for "bad air" indoors.[10] About one hundred years later, von Pettenkofer suggested that biological contaminants from human occupants caused indoor air problems, not CO_2, though he proposed using CO_2 as an indicator of vitiated air. Since that time, discussions of CO_2 in relation to IAQ and ventilation have evolved, focusing on the impacts of CO_2 on building occupants, how CO_2 relates to occupant perception of bioeffluents, the use of indoor CO_2 as a tracer gas



NIST Technical Note 2213

Indoor Carbon Dioxide Metric Analysis Tool

Andrew Persily
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This publication is available free of charge from:
https://doi.org/10.6028/NIST.TN.2213

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

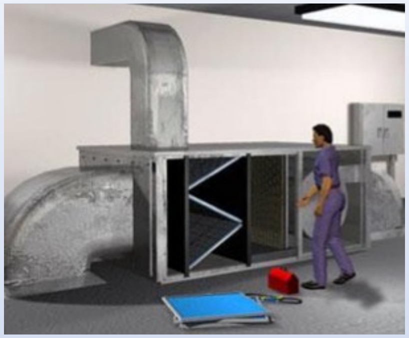
Innovation

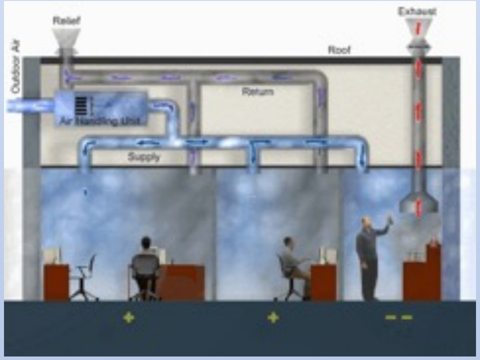
Do the right things

Make sure systems operating per design

Understand before making changes

We know how to do this!





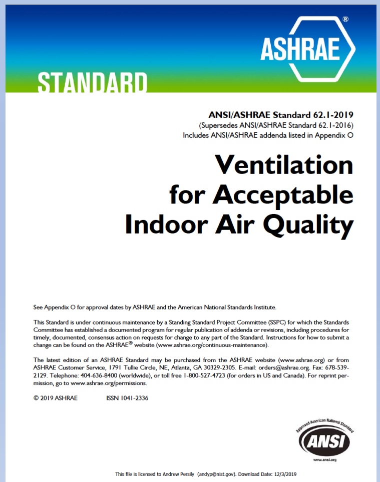
New stuff?

Localized or personal ventilation

Sensors

Ventilation control approaches

Revise ventilation/IAQ standards to
address operation, existing buildings
and airborne infection more directly



ASHRAE®

STANDARD

ANSI/ASHRAE Standard 62.1-2019
(Supersedes ANSI/ASHRAE Standard 62.1-2016)
Includes ANSI/ASHRAE addenda listed in Appendix O

Ventilation for Acceptable Indoor Air Quality

See Appendix O for approval dates by ASHRAE and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

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Wrap-up

Managing ventilation is nontrivial, but it's not rocket science

Each building/system is unique and dynamic

We have the knowledge and the tools

CO_2 is a tool; not everything is a nail

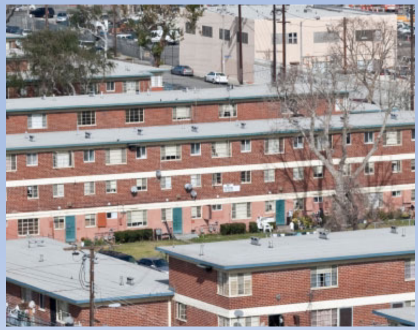
Measure and interpret with thought and care

You want innovation?

Operate and maintain systems as intended

Then get fancy with sensors, air distribution, …

Don't neglect the neglected buildings



Existing, Multi-family, Public housing

Older, lower-end without budgets and plaques

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https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=933724; https://www.youtube.com/watch?v=88XCmW8yIhs

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