Some Fun Facts about Breathing

- We breathe air in and out 12 times per minute, 17, 280 times per day
- The average breath is 500-600 mL (¼ of a 2 liter soda bottle)
- We breath in 25 x 10^{21} (sextillion) molecules with every inhale

Source: ANSI/ASHRAE

EASY Measurement of Indoor CO^2 for Good IAQ and Energy Savings

Fall 2024 ICCCFO Conference

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October 2, 2024

Content

- Indoor Air Quality (IAQ) Definitions
- Potential Indoor Air Contaminants
- Why IAQ Matters
- We breathe air in and out 17, 280 times per day
- The average breath is 500-600 mL (¼ of a 2 liter soda bottle)
- We breath in 111,000 ft^3 in one year (the volume of air in a 2500 ft^3 home 44 times)
- We breath in 25 x 10^{21} (sextillion) molecules with every inhale

Source: ANSI/ASHRAE

Indoor Air Quality Defined

ANSI/ASHRAE definition of IAQ:

"Air in which there are no known contaminants at harmful concentrations, as determined by cognizant authorities, and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction."

EPA definition of IAQ:

"IAQ refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants…"

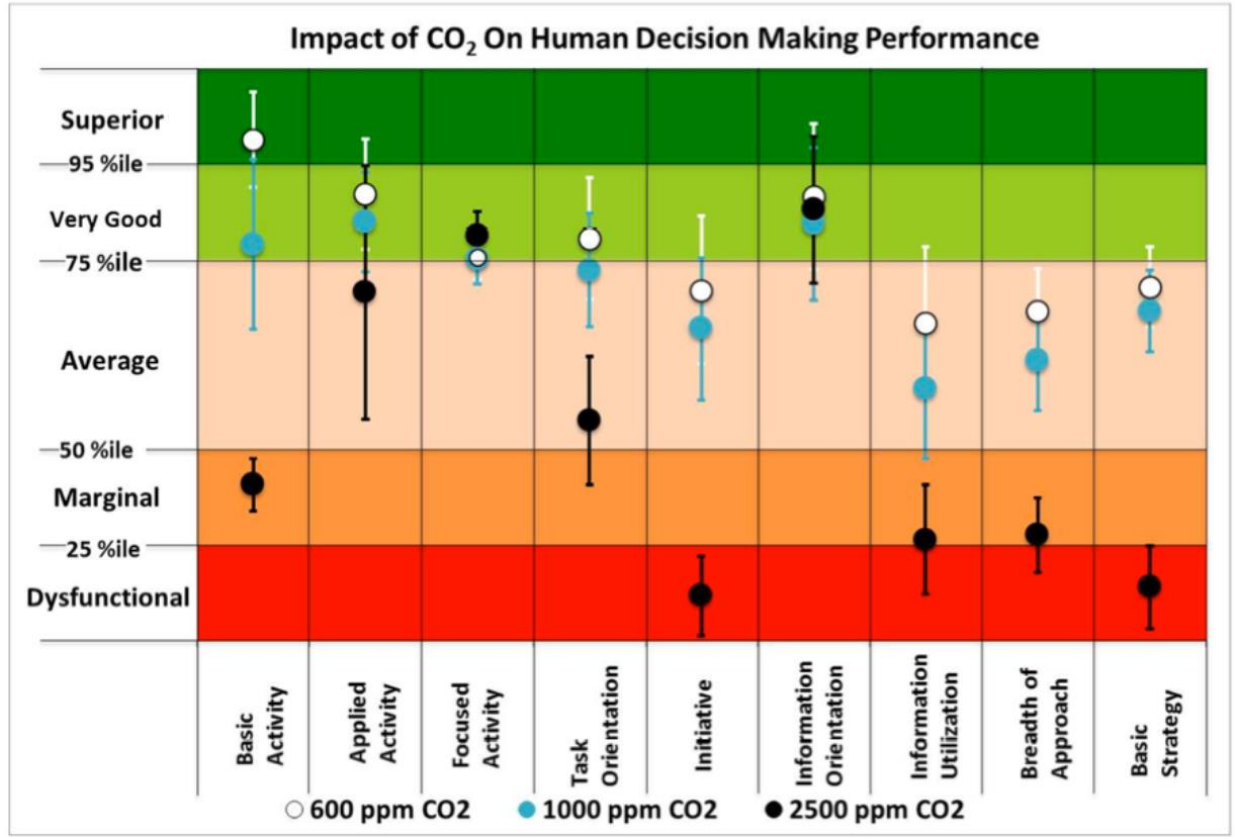
Potential Indoor Air Contaminants

There is a long list of potential air pollutants

- VOCs – volatile organic compounds
  - Building materials
  - Furniture
  - Flooring, carpeting
  - Cleaning supplies
- Biological
  - Mold
  - Bacteria/viruses
- Fine Particulates
  - Smoke
- CO^2
  - People
- etc

Why Good IAQ Matters

- Obvious health risks to poor IAQ
- Various studies have shown that high CO^2 concentration can impair decision making



Source: Berkeley Lab Report, " Elevated Indoor Carbon Dioxide Impairs Decision-Making Performance, 2012

Focus on the EASY Stuff First

Measure CO^2 Concentration as a proxy for the rate of outdoor air ventilation

ASHRAE agrees this is a sound method but….

…it does not prove good IAQ

ASHRAE Position Document on Indoor Carbon Dioxide

Approved by ASHRAE Board of Directors
February 2, 2022

Some History on CO^2 and Building Ventilation

- CO^2 has been discussed in the context of building ventilation since the 17th century
- In the early 20th century, some studies showed that warmth combined with smells in a crowded room were sources of discomfort in poorly ventilated rooms

Source: ASHRAE Position Document on Indoor CO^2

Some History on CO^2 in Relation to Ventilation Rates in Buildings (cont.)

- Based on some studies on body odor perception, this was used as a criterion for ventilation rate requirements of 15 to 20 cfm per person
- CO^2 concentration was considered to be an indicator of body odor and in 1989 ASHRAE decided to set maximum CO^2 at 1000 ppm but subsequently removed this limit due to much misunderstanding about it's actual significance

Source: ASHRAE Position Document on Indoor CO^2

Ventilation Rate Requirements for Illinois Community Colleges

- The Illinois Energy Conservation Code applies public or private buildings
  - Capital Development Board reviews and adopts the International Energy Conservation Code (IECC)
  - Current code is the 2021 IECC Code with Illinois Amendments
    - Ventilation – follow the International Mechanical Code (IMC) or ASHRAE 90.1, 2021

Ventilation Rate Standards/Codes (continued)

SAMPLE TABLE FROM 2021 IMC, ASHRAE TABLES ARE THE SAME

TABLE 403.3.1.1 MINIMUM VENTILATION RATES

OCCUPANCY CLASSIFICATION	OCCUPANT DENSITY #/1000 FT^2 [a]	PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R_p CFM/PERSON	AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R_a CFM/FT^2 [a]	EXHAUST AIRFLOW RATE CFM/FT^2 [a]
Education				
Art classroom[g]	20	10	0.18	0.7
Auditoriums	150	5	0.06	—
Classrooms (ages 5–8)	25	10	0.12	—
Classrooms (age 9 plus)	35	10	0.12	—
Computer lab	25	10	0.12	—
Corridors (see "Public spaces")	—	—	—	—

For a 1000 ft^2 classroom with 35 students

470 CFM or
13.4 CFM/person

CO^2 Link to Ventilation Rate

For average room occupancy:

Ventilation and Resultant CO_2 Concentrations

Carbon Dioxide	Outside Air (cfm per person)	CO_2 Differential (inside/outside)
800 ppm suggests about	20 cfm (or less)	500 ppm
1,000 ppm suggests about	15 cfm (or less)	650 ppm
1,400 ppm suggests about	10 cfm (or less)	1,050 ppm
2,400 ppm suggests about	5 cfm (or less)	2,050 ppm

Note: *The* ***CO_2*** *values in this table are approximate, and based on a constant number of sedentary adult occupants, a constant ventilation rate, an outdoor air* ***CO_2*** *concentration of about 380 ppm, and good mixing of the indoor air.*

Source: Dr. Rich Hill, Washington State University

EASY Way to Measure CO^2

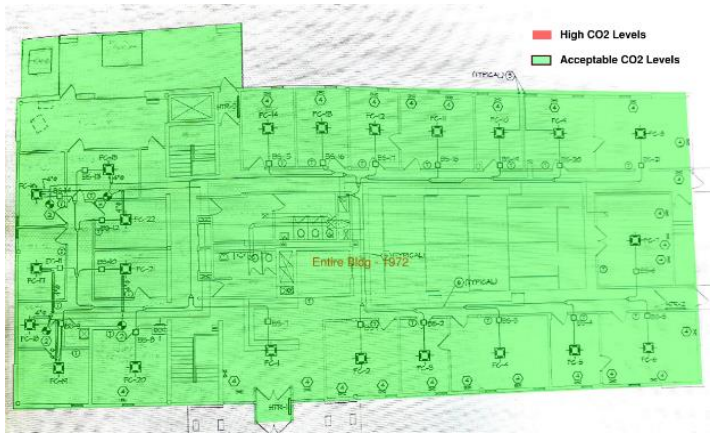
- Use a portable and inexpensive meter
- Easy to calibrate (measure CO^2 concentration outdoors before starting indoor measurements)
- Walk from room to room
- This example is quick response (stable reading within one minute)

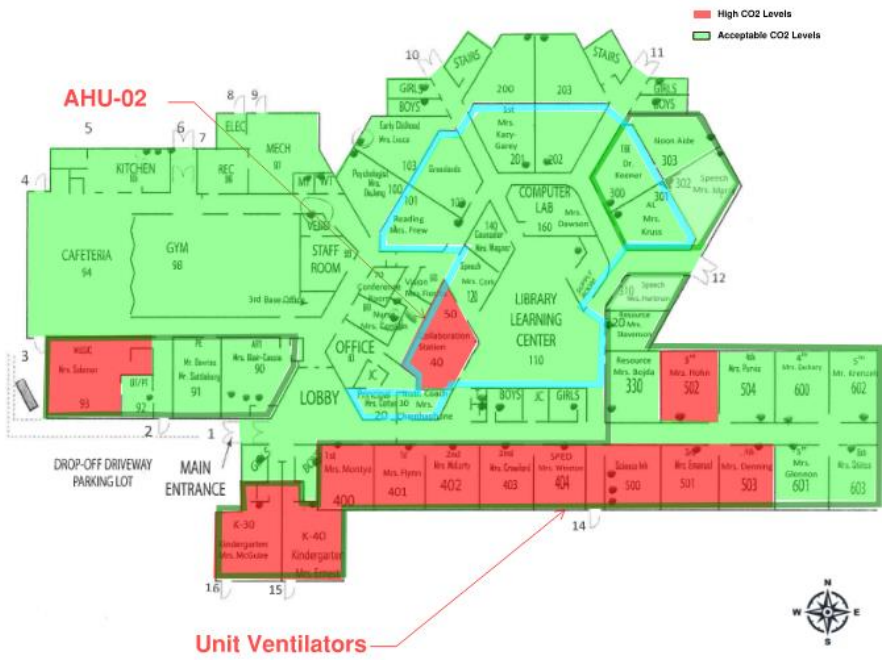
Not as EASY But More Data

- Connects to Wi-Fi network
- Trends are accessible for remote viewing and download
- Useful for deeper level of troubleshooting

Case Study

- IAQ measurement in 14 buildings
- Total of 1,353,000 sq ft





Ventilation Rate Impact on Utility Bills

- The median educational facility in Illinois consumes about 68k BTU/sq ft and pays $1.25 / ft^2 per year
- 40% is for heating and cooling and 40% of that is specifically for treating the fresh air (assumes 30% fresh air rate) - $0.20/$ft^2$ is for treating ventilation air
- For a 50,000 ft^2 building,
  - total annual energy bill is about $62,500
  - **treating the fresh air costs about $10,000/yr**

Source: MicroSoft AI Copilot

THANK YOU

Questions ?