Ventilation for Acceptable Indoor Air Quality

Part 3 - Recognizing the Pitfalls of CO_2 Ventilation Control

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Loris, South Carolina


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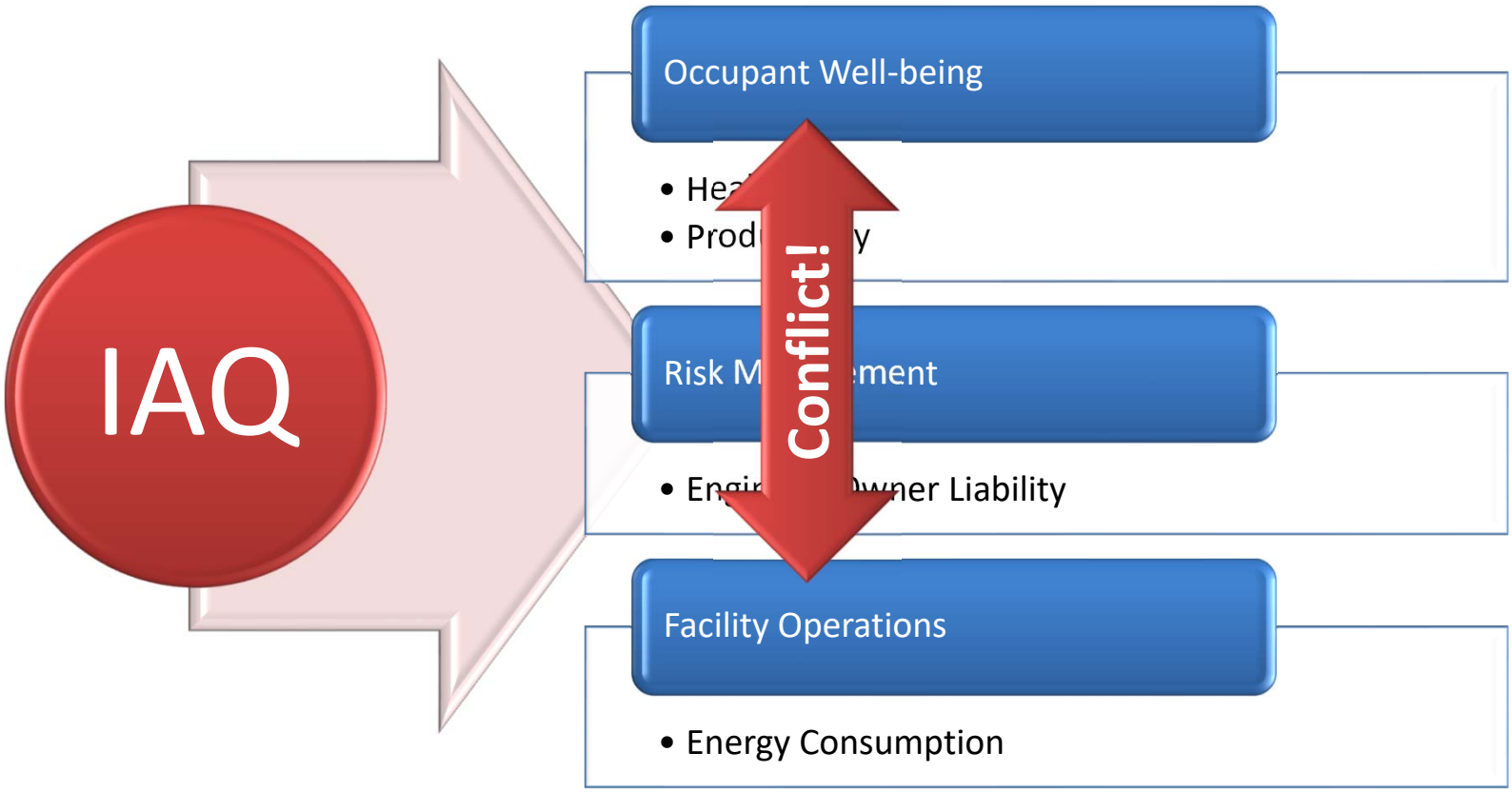
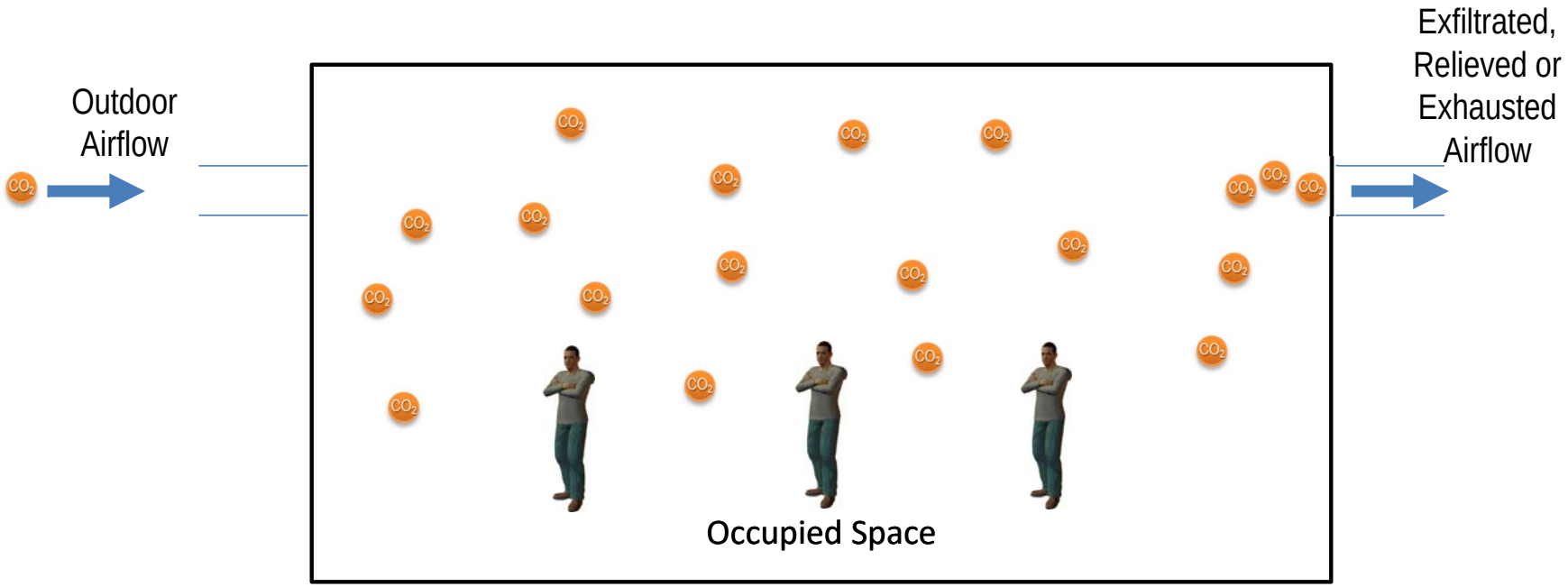
IS YOUR OFFICE KILLING YOU?
The dangers of sick buildings
By Michelle Conlin
PAGE 114

Indoor Air Quality Affects …



CO_2 and Ventilation - @ Steady State

Constant Outdoor Air Dilution Rate, Fixed Population



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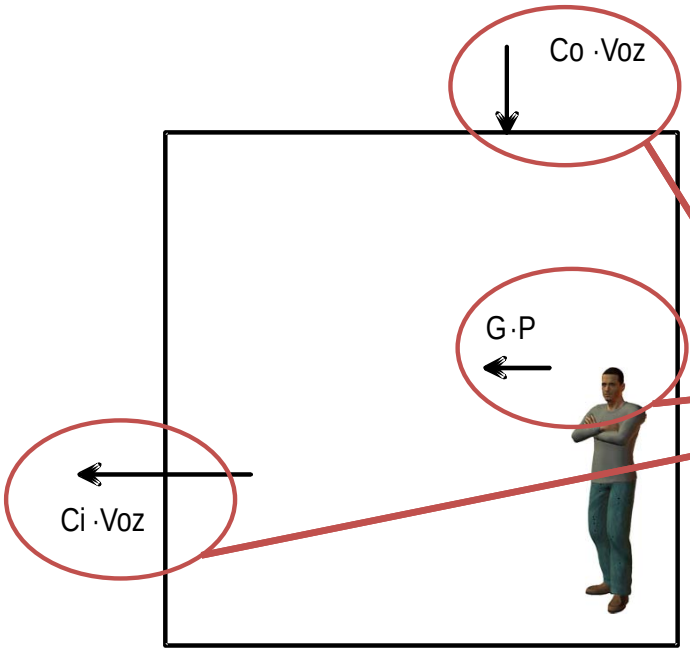
CO_2 and Ventilation



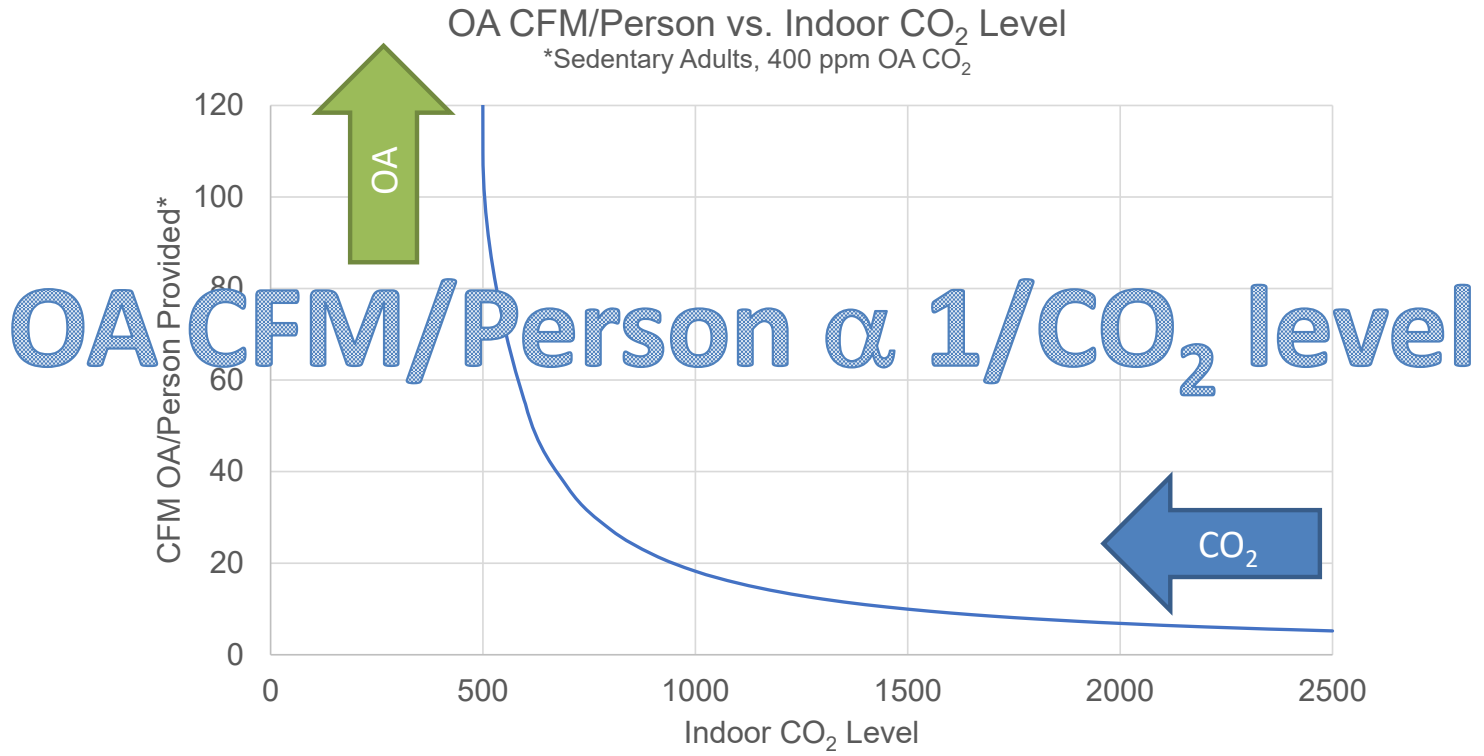
Co = Outdoor CO_2 concentration (ft^3 CO_2/ft^3 air)
Ci = Indoor CO_2 concentration (ft^3 CO_2/ft^3 air)
Voz = Q_{OA} = Outside Airflow Rate (ft^3air/min)
Vo=Outside Airflow Rate/Person ((ft^3air/min)/person)
G = CO_2 generation rate of the occupant (ft^3 CO_2/min)
P = Number of occupants

Steady-state Mass Balance: In = Out
Co·Voz + G·P = Ci·Voz

Can be rearranged as:

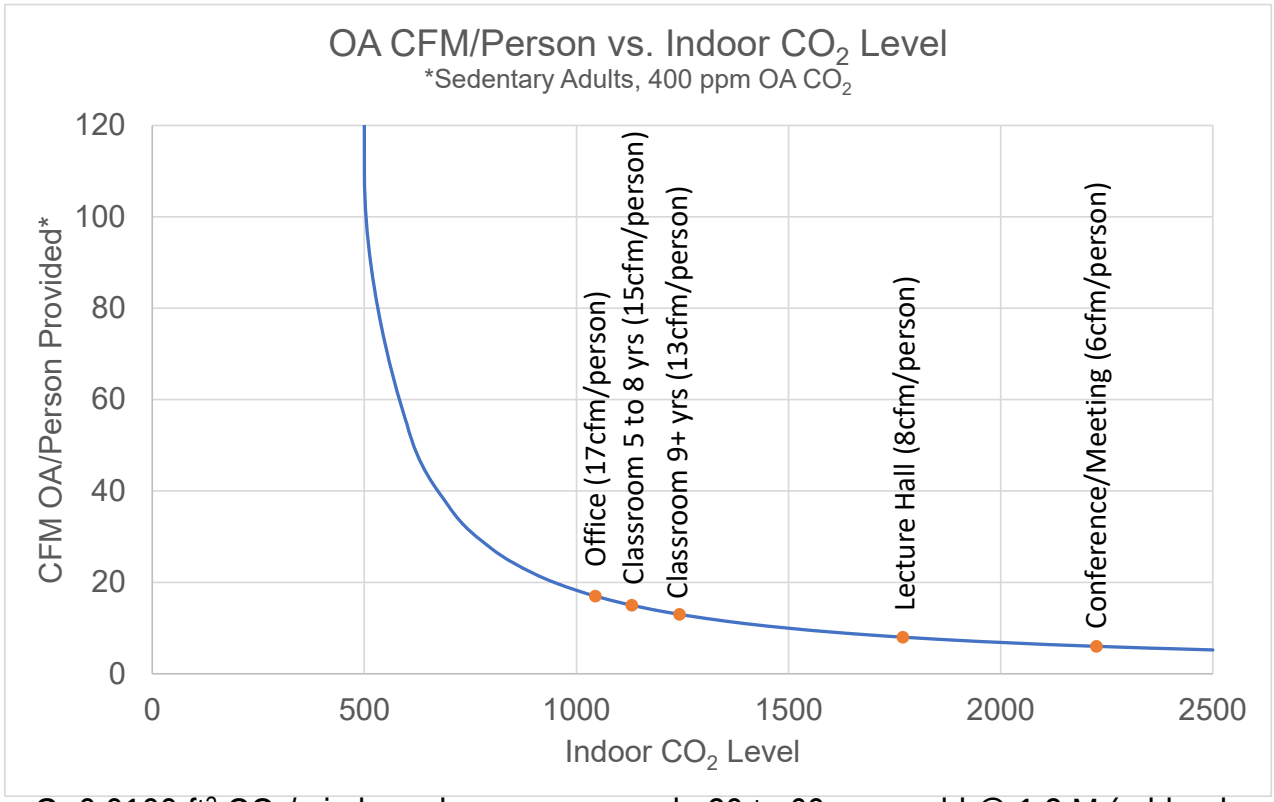
G / (Ci – Co) = Voz/P = Vo = OA CFM/person

CO_2 and Ventilation are Codependent



Note: G=0.0100 ft^3 CO_2/min based on average male 20 to 60 years old @ 1.3 M (addendum ab)

CO_2 Levels and the IMC/ASHRAE 62.1



Note: G=0.0100 ft^3 CO_2/min based on average male 20 to 60 years old @ 1.3 M (addendum ab)

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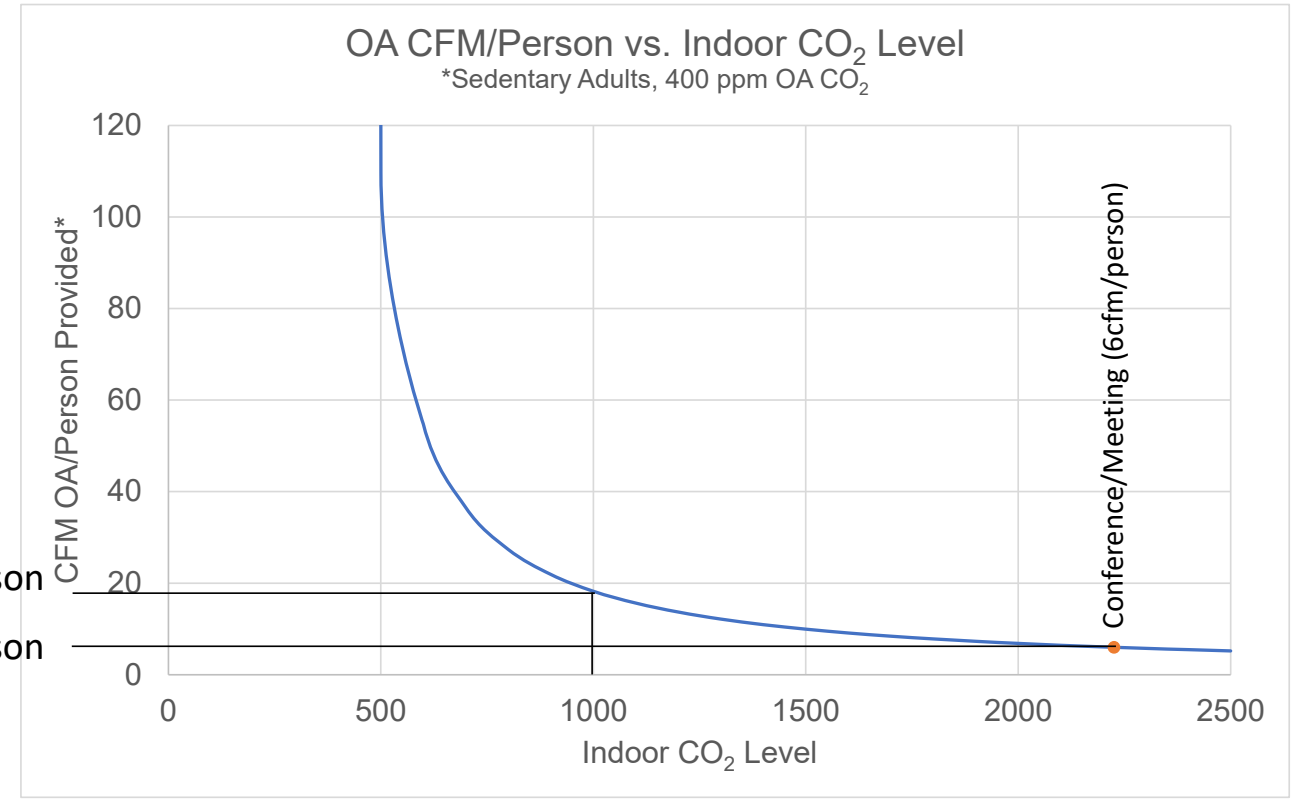
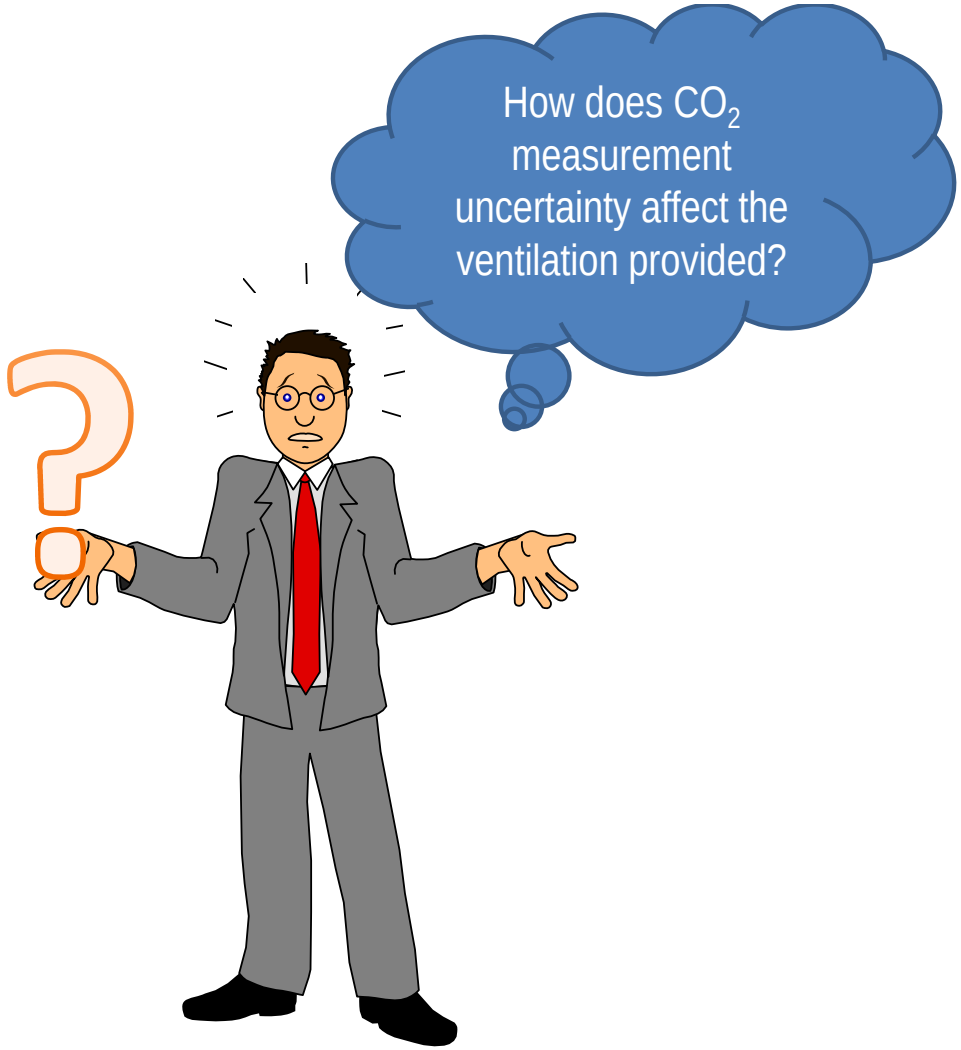
Design to 62.1/IMC – Operate @ 1,000 ppm

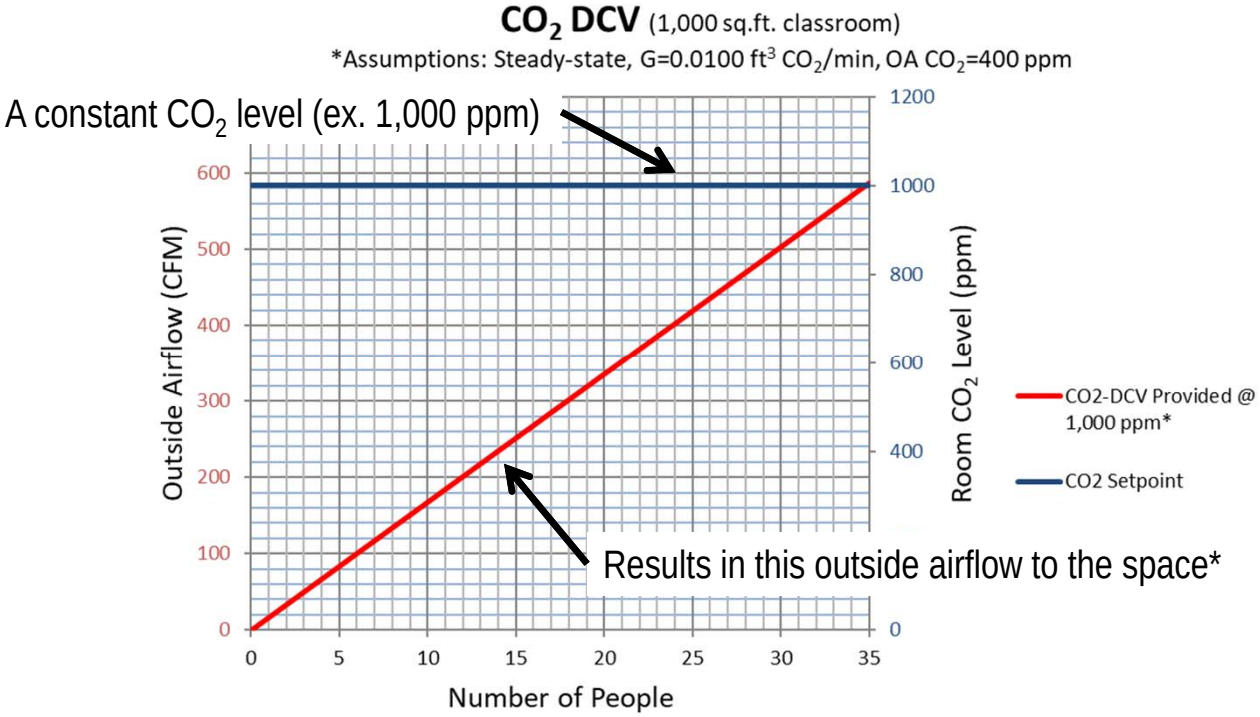


Operate: ≈ 17 CFM/person

Design: 6 CFM/person

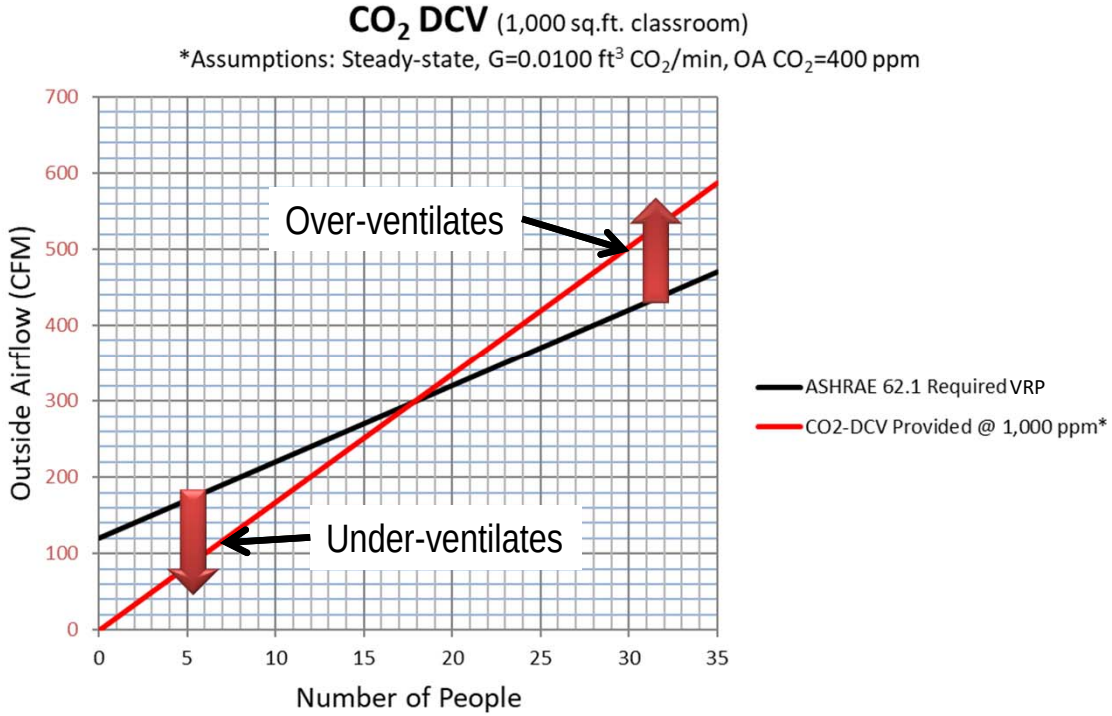

How does CO_2 measurement uncertainty affect the ventilation provided?

Fixed Setpoint CO_2-DCV



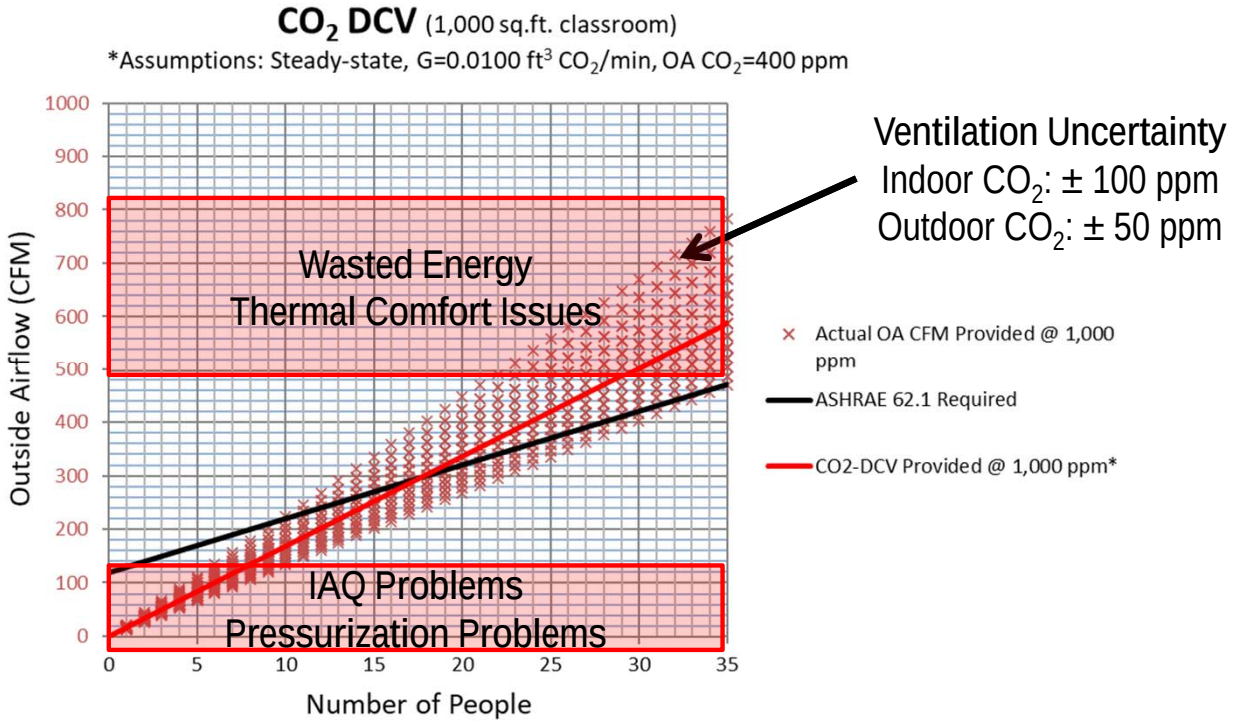
Note: G=0.0100 ft^3 CO_2/min based on average male 20 to 60 years old @ 1.3 M (addendum ab)

Fixed Setpoint CO_2-DCV vs. ASHRAE 62.1



Note: G=0.0100 ft^3 CO_2/min based on average male 20 to 60 years old @ 1.3 M (addendum ab)

CO_2-DCV Ventilation Uncertainty



Note: G=0.0100 ft^3 CO_2/min based on average male 20 to 60 years old @ 1.3 M (addendum ab)

Age vs. CO_2 Generation Rates and Corresponding OA CFM for Ci-Co=600 ppm

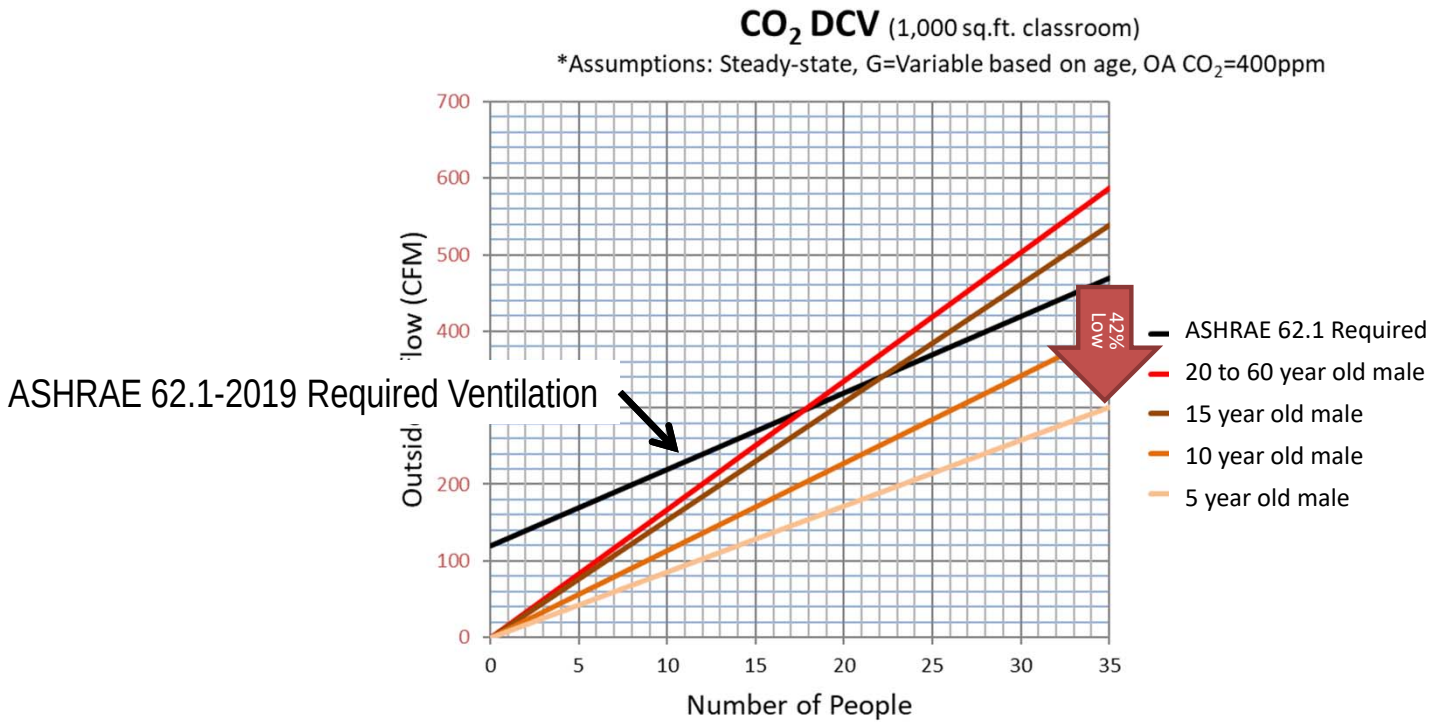
Age | Sex | Diet | Body Mass | Activity Level

Normative Appendix D Calculations (Addendum ab)

Age	Sex	RQ Assumed	BMR Calc. Coef. Table D1.2.2.		Mass (kg) Table D1.2.3.	BMR eq. D1.2.6.1.	M Table 1.2.4.1.	G= RQ·BMR·M·*k* L/S	G= RQ·BMR·M·*k* CFM	OA CFM @Ci-Co=600
5	M	0.85	0.095	2.110	18.6	3.877	1.3	0.0024	0.0052	8.6
10	M	0.85	0.095	2.110	31.8	5.131	1.3	0.0032	0.0068	11.4
15	M	0.85	0.074	2.754	56.8	6.957	1.3	0.0044	0.0093	15.4
20	M	0.85	0.063	2.896	71.6	7.407	1.3	0.0047	0.0099	16.4
30	M	0.85	0.048	3.653	78.4	7.416	1.3	0.0047	0.0099	16.5
40	M	0.85	0.048	3.653	83.6	7.666	1.3	0.0048	0.0102	17.0
50	M	0.85	0.048	3.653	83.4	7.656	1.3	0.0048	0.0102	17.0
60	M	0.85	0.048	3.653	82.6	7.618	1.3	0.0048	0.0101	16.9
Avg. 20 to 60	M							0.0047	0.0101	16.8

Source: ASHRAE 62.1 Normative Appendix D (proposed addendum ab)

Fixed Setpoint CO_2-DCV and Occupant Age



Note: G based on various age males @ 1.3 M (addendum ab)

Activity vs. OA CFM/person

Table 1.2.4.1. *M* values for various activities [5]

Activity	Males		Females	
	Average *M*	*M* Range	Average *M*	*M* Range
Aerobic dancing – low intensity	3.51		4.24	
Aerobic dancing – high intensity	7.93		8.31	
Calisthenics	5.44			
Child care (unspecified)			2.5	
Climbing stairs	5.0			
Dancing	5.0		5.09	
Eating and drinking	1.4		1.6	
Housework (unspecified)			2.8	2.5 to 3.0
Office worker – Filing	1.3		1.5	
Office worker – Reading	1.3		1.5	
Office worker – Sitting at desk	1.3			
Office worker – Standing/moving around	1.6			
Office worker – Typing	1.8		1.8	
Office worker – Writing	1.4		1.4	
Reading	1.22		1.25	
Sleeping	1.0		1.0	
Sitting quietly	1.2		1.2	
Sitting on a bus/train	1.2			
Standing	1.4		1.5	
Walking around/strolling	2.1	2.0 to 2.2	2.5	2.1 to 2.9
Walking quickly	3.8			
Walking slowly	2.8	2.8 to 3.0	3.0	

Table 1.2.4.2. Values of physical activity levels (*M*) [4]

Activity	*M*	Range
Calisthenics – light effort	2.8	
Calisthenics – moderate effort	3.8	
Calisthenics – vigorous effort	8.0	
Child care		2.0 to 3.0
Cleaning, sweeping – moderate effort	3.8	
Custodial work – light	2.3	
Dancing – aerobic, general	7.3	
Dancing – general	7.8	
Health club exercise classes – general	5.0	
Kitchen activity – moderate effort	3.3	
Lying or sitting quietly		1.0 to 1.3
Sitting reading, writing, typing	1.3	
Sitting at sporting event as spectator	1.5	
Sitting tasks, light effort (e.g. office work)	1.5	
Sitting quietly in religious service	1.3	
Sleeping	0.95	
Standing quietly	1.3	
Standing tasks, light effort (e.g. store clerk, filing)	3.0	
Walking, less than 2 mph, level surface, very slow	2.0	
Walking, 2.8 mph to 3.2 mph, level surface, moderate pace	3.5	

> 6X

$G / (Ci - Co) = Vo =$ OA CFM/person

$M \alpha G \alpha$ OA CFM/person!

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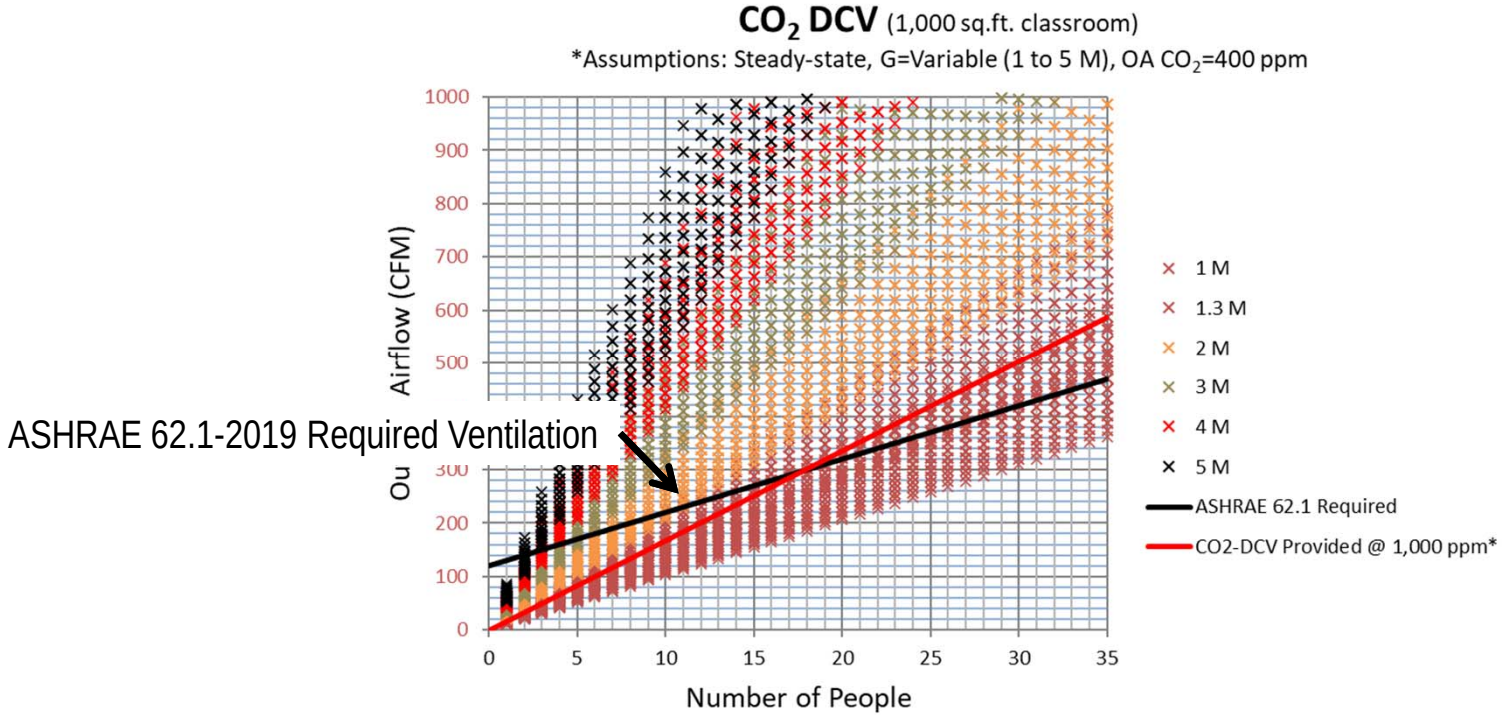
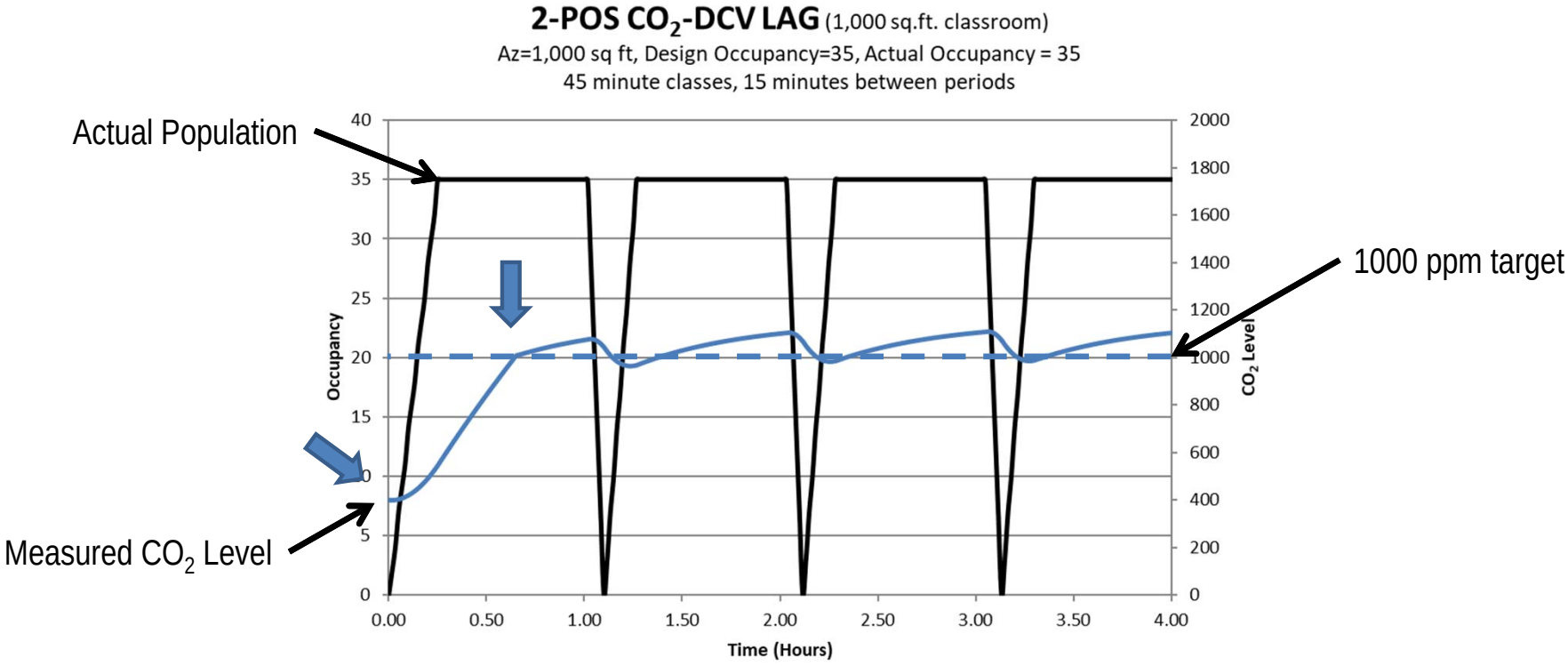
Activity Level Adds More Uncertainty



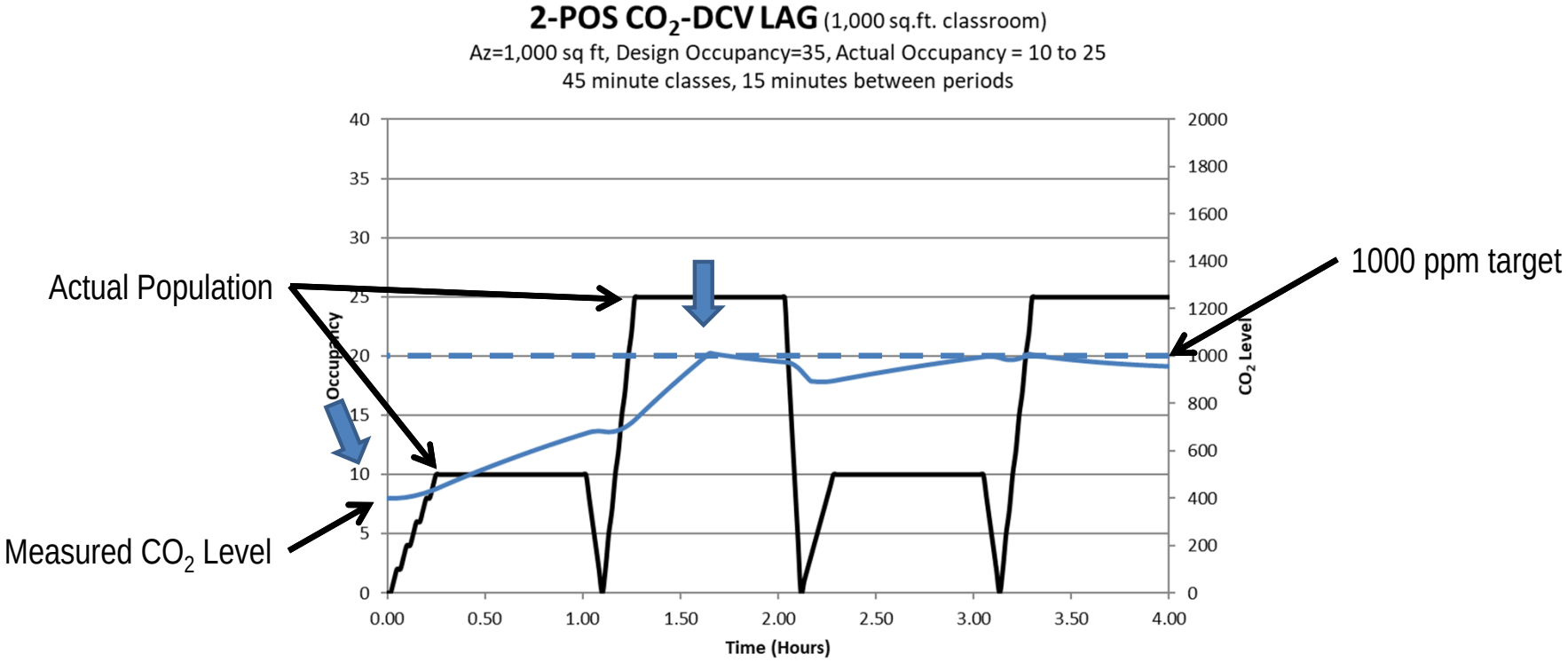
Note: G based on average male 20 to 60 years old (addendum ab)

Fixed Setpoint CO_2-DCV vs. ASHRAE 62.1

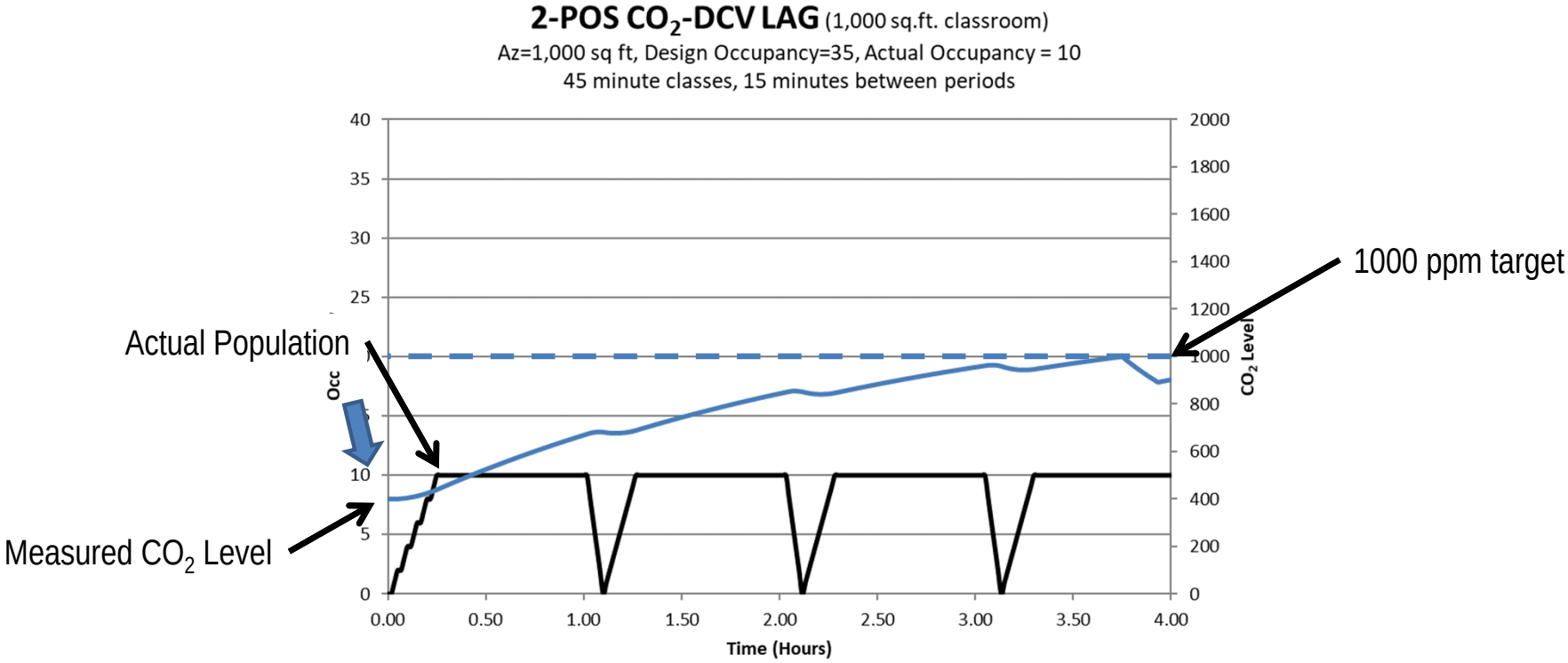
Good or Bad IAQ?



Better or Worse?



Best or Worst?



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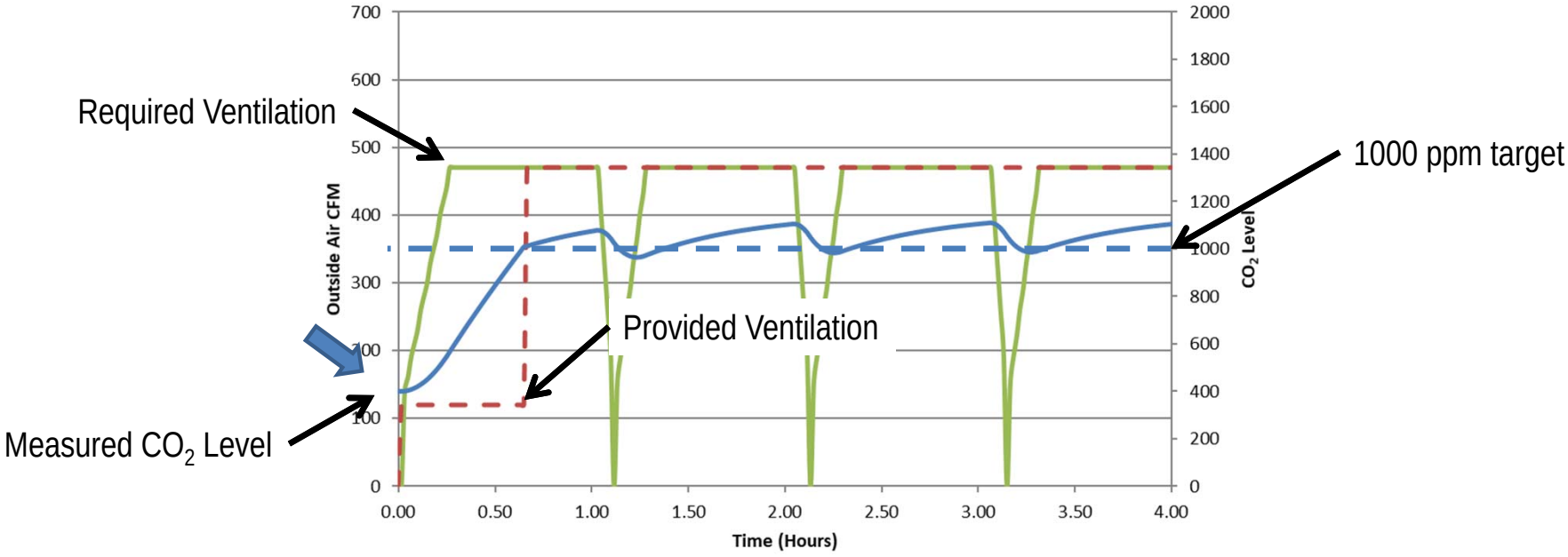

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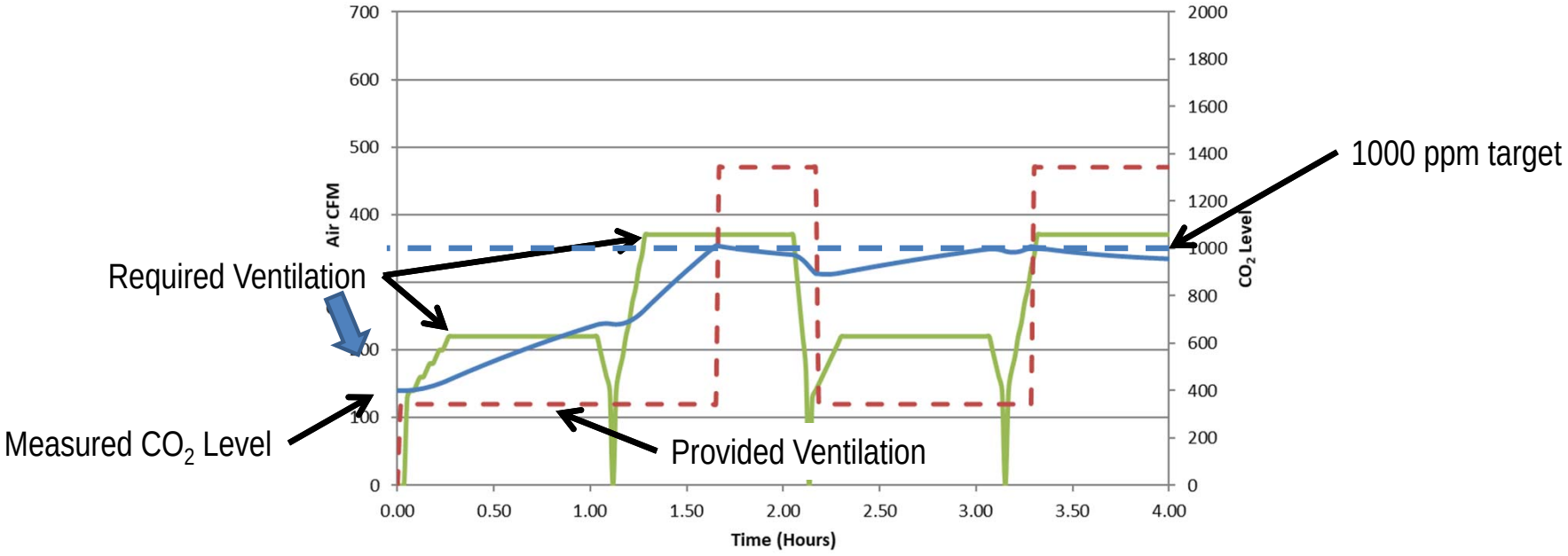

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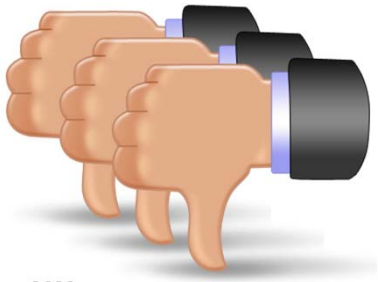

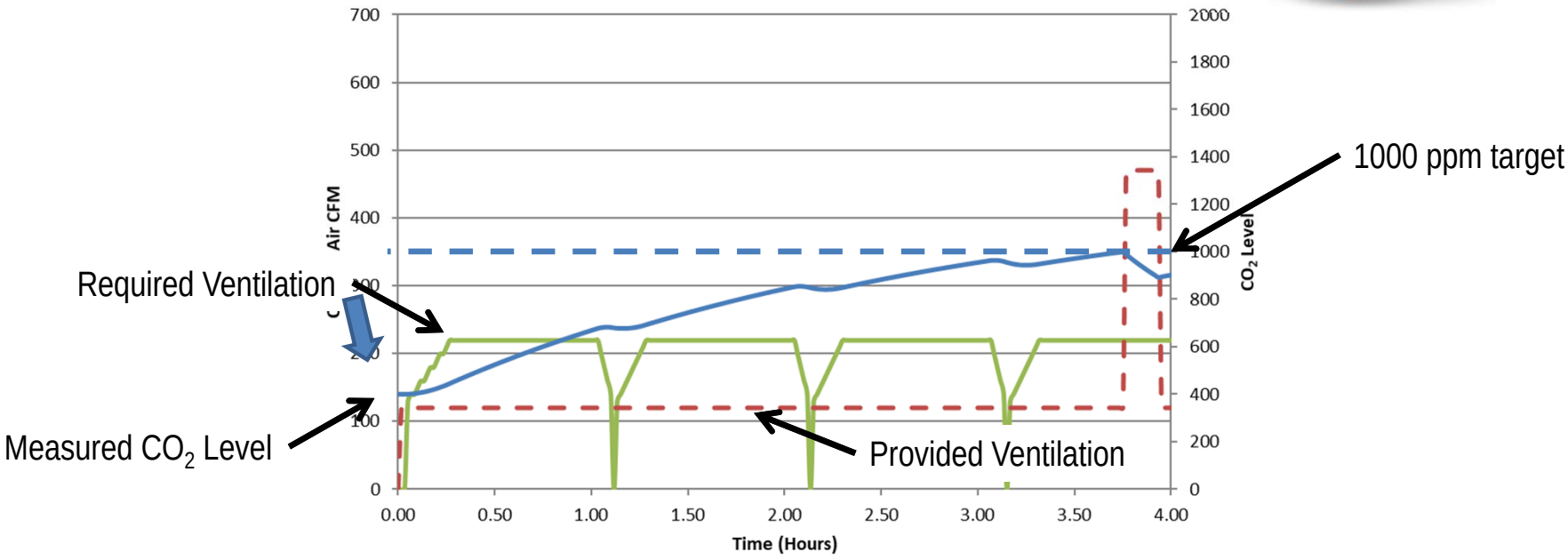

You do not know how much OA ventilation you have provided!

Thank You!

Questions? More information?

AskDave@EngineeredSalesCorp.com