COVID-19 RESOURCES About Services Contact

Occupational Health Clinics for Ontario Workers Inc.
Centres de santé des travailleurs (ses) de l'Ontario Inc.

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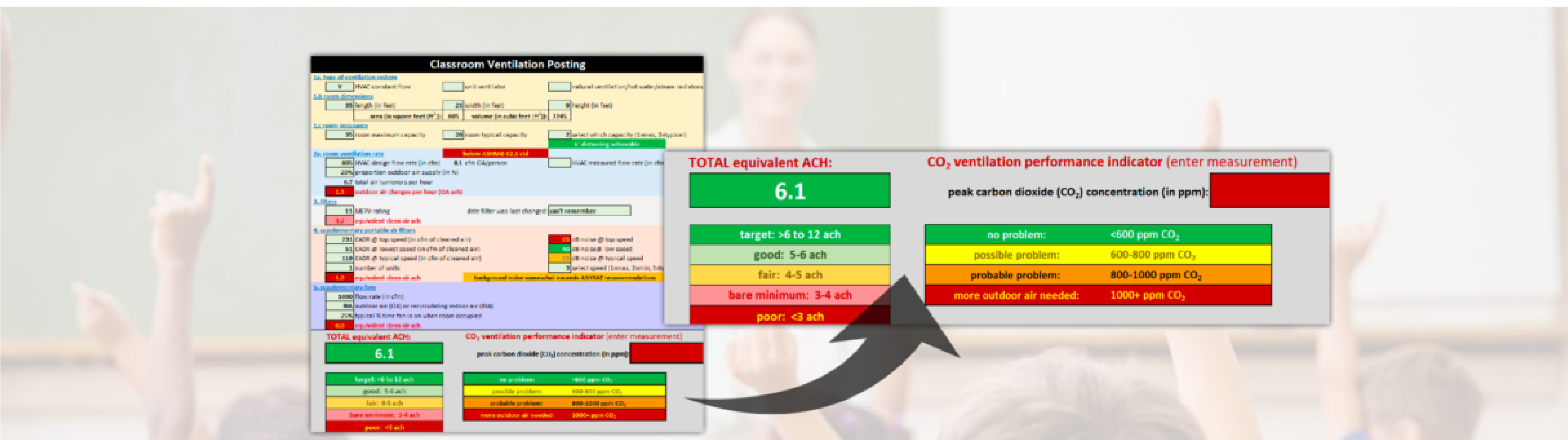
Classroom* Ventilation Calculation Tool

An Excel-based tool to assist you in determining the adequacy of the ventilation in your classroom

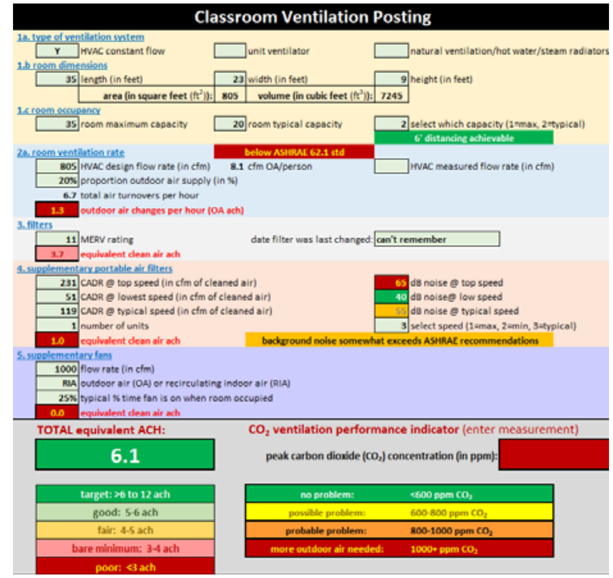
*Tool can also be used to evaluate single offices and small meeting rooms.
A more generic version is in development.



Welcome!

- We hope to help you use the classroom ventilation calculation tool
- Adequate ventilation has been talked about a lot, but no one has given anyone the specifics about how to evaluate your classroom/office/meeting room
- We hope this tool will fill in this gap

1. First, together we'll go over the sections of the spreadsheet,
2. Then, we'll have breakout groups where we can discuss specific issues/questions you would like to raise
3. Finally, we'll get back together and deal with any outstanding questions

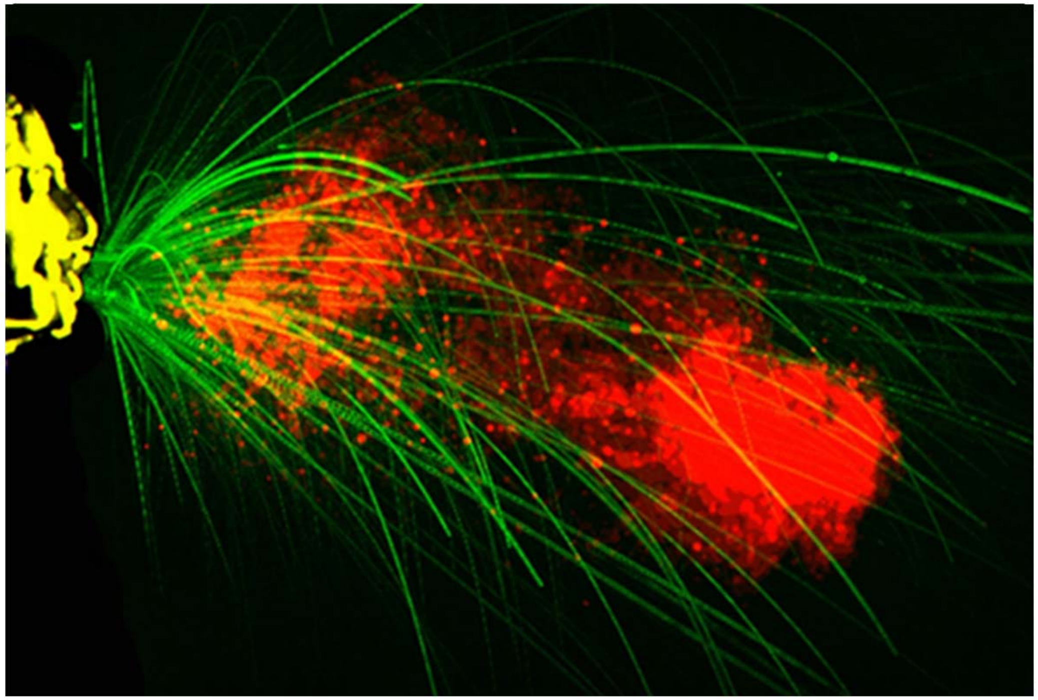


Facilitators:

These people will act as resource persons for the breakout session (all of whom have training in occupational hygiene):

Dorothy Wigmore
Kevin Hedges
Masood Ahmed
Murray Lawrence
Valerie Wolfe
John Oudyk

Why do we care about ventilation?



"plume" and "room" dispersion aerodynamics ("plume" independent of room air flow patterns) – stop it with a mask

Figure 1: Image reproduction showing the semi-ballistic largest drops, visible to the naked eye, and on the order of mm, which can overshoot the puff at its early stage of emission [14, 15]. The puff continues to propagate and entrain ambient air as it moves forward, carrying its payload of a continuum of drops [13], over distances up to 8 meters for violent exhalations such as sneezes [17].

https://www.sciencedirect.com/science/article/pii/S0301932220305498

We already knew IAQ was important

Original Articles

The Effect of Low Ventilation Rates on the Cognitive Function of a Primary School Class

David A. Coley, Rupert Greeves & Brian K. Saxby

Pages 107-112 | Published online: 29 Mar 2016

Download citation https://doi.org/10.1080/14733315.2007.11683770

References Citations Metrics Reprints & Permissions Get access

Abstract

Several studies have suggested that recommended ventilation rates are not being met within schools. However these studies have not included an evaluation of whether or not this failure might have an impact on pupil performance and learning outcome. The work reported here was designed as an initial investigation into this question.

Using the Cognitive Drug Research computerised assessment battery to measure cognitive function, this study demonstrates that the attentional processes of school children are significantly slower when the level of CO_2 in classrooms is high. The effects are best characterised by the Power of Attention factor which represents the intensity of concentration at a particular moment, with faster responses reflecting higher levels of focussed attention. Increased levels of CO_2 (from a mean of 690 ppm to a mean of 2909 ppm) led to a decrement in Power of Attention of approximately 5%. Thus, in a classroom where CO_2 levels are high, students are likely to be less attentive and to concentrate less well on what the teacher is saying, which over time may possibly lead to detrimental effects on learning and educational attainment. The size of this decrement is of a similar magnitude to that observed over the course of a morning when students skip breakfast. https://www.tandfonline.com/doi/abs/10.1080/14733315.2007.11683770

Centers for Disease Control and Prevention

MMWR

https://www.cdc.gov/mmwr/volumes/70/wr/mm7021e1.htm

Morbidity and Mortality Weekly Report

Early Release / Vol. 70

May 21, 2021

Mask Use and Ventilation Improvements to Reduce COVID-19 Incidence in Elementary Schools — Georgia, November 16–December 11, 2020

Jenna Gettings, DVM[1,2,3]; Michaila Czarnik, MPH[1,4]; Elana Morris, MPH[1]; Elizabeth Haller, MEd[1]; Angela M. Thompson-Paul, PhD[1]; Catherine Rasberry, PhD[1]; Tatiana M. Lanzieri, MD[1]; Jennifer Smith-Grant, MSPH[1]; Tiffiany Michelle Aholou, PhD[1]; Ebony Thomas, MPH[2]; Cherie Drenzek, DVM[2]; Duncan MacKellar, DrPH[1]

https://www.cdc.gov/mmwr/volumes/70/wr/mm7021e1.htm

What does this mean?

- **Masks** alone: 37% reduction in infections
- **Ventilation:** 39% reduction in infections
  - Dilution ventilation alone: 35% reduction
  - Dilution ventilation **& filtration**: **48% reduction**

So why are we policing masking but not ventilation?

Summary

What is already known about this topic?

Kindergarten through grade 5 schools educate and address the students' physical, social, and emotional needs. Preventing SARS-CoV-2 transmission in schools is imperative for safe in-person learning.

What is added by this report?

COVID-19 incidence was 37% lower in schools that required teachers and staff members to use masks and 39% lower in schools that improved ventilation. Ventilation strategies associated with lower school incidence included dilution methods alone (35% lower incidence) or in combination with filtration methods (48% lower incidence).

What are the implications for public health practice?

Mask requirements for teachers and staff members and improved ventilation are important strategies in addition to vaccination of teachers and staff members that elementary schools could implement as part of a multicomponent approach to provide safer, in-person learning environments.

https://www.cdc.gov/mmwr/volumes/70/wr/mm7021e1.htm

PHAC

https://www.canada.ca/en/public-health/services/diseases/2019-novel-coronavirus-infection/guidance-documents/guide-indoor-ventilation-covid-19-pandemic.html

Improving ventilation

There are many ways to improve ventilation to mitigate the transmission of infectious diseases. The most appropriate measures depend on the characteristics of the particular setting. One way to improve ventilation is by opening exterior doors and windows for a few minutes, ideally with more than one open at a time.

Opening windows in winter may not always be comfortable or possible. Doing so for a few minutes at a time during the day can still improve air quality, with minimal impact on the indoor temperature. If occupants will be indoors for longer periods, for example at schools, occupants should have regular outdoor breaks, to allow for ventilation of the room.

An HVAC system will exchange indoor air a certain number of times per hour as a part of regular operation. To increase ventilation, run your HVAC system fan continuously at a low speed to provide air movement and filtration without unwanted draft. Within non-residential buildings, run the system for 2 hours at maximum outside airflow before and after the building is occupied. Bathroom and kitchen exhaust fans that are vented to the outside can also be used to help remove potentially contaminated air, where appropriate.

Most HVAC systems will recirculate some air through the indoor space, making it important to:

- ensure that filters are well sealed without a bypass
- clean or change your filters regularly per manufacturer's recommendations
- select filters with higher MERV ratings that are more efficient at removing particles

This should be done within the specifications of your HVAC system and in consultation with an HVAC professional.

Portable or ceiling fans, or single unit air conditioners may circulate air within the room, but they do not exchange air or improve ventilation. If using a window air conditioner unit or a fan is necessary, aim the air stream away from people to reduce the spread of potentially infectious droplets or particles.

PHO Guidance

ASHRAE provides additional guidance for HVAC systems for the COVID-19 pandemic which can be applied with the support of professionals who can assess specific buildings for measures most appropriate and feasible.[54] Professionals can also assess the outdoor air ventilation rates within a space that has a mechanical HVAC system.[55] The CSA guidance for workplaces during the pandemic reinforces that air exchange rates should be modified on a building-by-building basis with careful evaluation of the ventilation system because adjustments can lead to issues related to thermal comfort and humidity, and undesired effects on air circulation.[56]

Indoor carbon dioxide (CO_2) measurement as an indicator of ventilation

Indoor CO2 levels may be used as an indicator of ventilation as part of a professional assessment and are typically evaluated based on time-averaged readings. High indoor CO2 levels can potentially identify spaces with poor ventilation rates but CO2 is not an indicator of COVID-19 transmission risk. If CO2 monitors are being considered for people with no background on their use, then interpretation of levels and corresponding actions are challenges that need careful consideration.

The indoor CO_2 level is an indicator for ventilation. CO_2 is exhaled by people and can build up in indoor spaces compared to normal outdoor ground-level CO_2.[57] Ventilation can lower indoor CO_2 levels by introducing fresh outdoor air, leading to its use as a proxy for indoor air removal or dilution. There are a variety of ways CO_2 levels can be measured and analysed, but in general measurements are averaged over a period of time to capture the effect of ventilation on CO_2 levels. Measurements are also carried out in the occupied area of a room with the sensors located away from windows, doors, and ventilation grilles.[49] Follow up measurements can be made if ventilation is increased in a space to verify the effectiveness of the changes. Accuracy of CO_2 sensors used, placement and setting (e.g. large volume spaces) and occupant activity should be considered when reviewing the data. As well, manufacturer's guidance on calibration procedures should be followed.

https://www.publichealthontario.ca/-/media/documents/ncov/ipac/2020/09/covid-19-hvac-systems-in-buildings.pdf?la=en

MOL advice:

https://www.ontario.ca/page/manufacturing-health-and-safety-during-covid-19

the only mention of "ventilation"

Workplace sanitation

Coronaviruses are spread person to person through close contact, including at work. While employers always have an obligation to maintain clean worksites, that obligation is under sharper focus due to COVID-19.

Here are some tips for employers to use:

- Provide ways to properly clean hands, by providing access to soap and water or alcohol-based hand sanitizer.
- Have all employees and visitors wash their hands thoroughly with soap and water before entering the workplace and after contact with surfaces others have touched.
- Include handwashing before breaks and at shift changes.
- Provide a safe place for workers to dispose of used sanitizing wipes and personal protective equipment.
- Clean washroom facilities.
- Sanitize commonly touched surfaces or areas such as entrances, counters, washrooms and kitchens.
- Sanitize shared equipment (where sharing of equipment cannot be avoided).
- Consider a captive boot/personal protective equipment program to limit this equipment's use outside of the production/processing environment.
- Post hygiene instructions in English or French and the majority workplace language so everyone can understand how to do their part.
- Introduce more fresh air by increasing the ventilation system's air intake or opening doors and windows. Avoid central recirculation where possible.

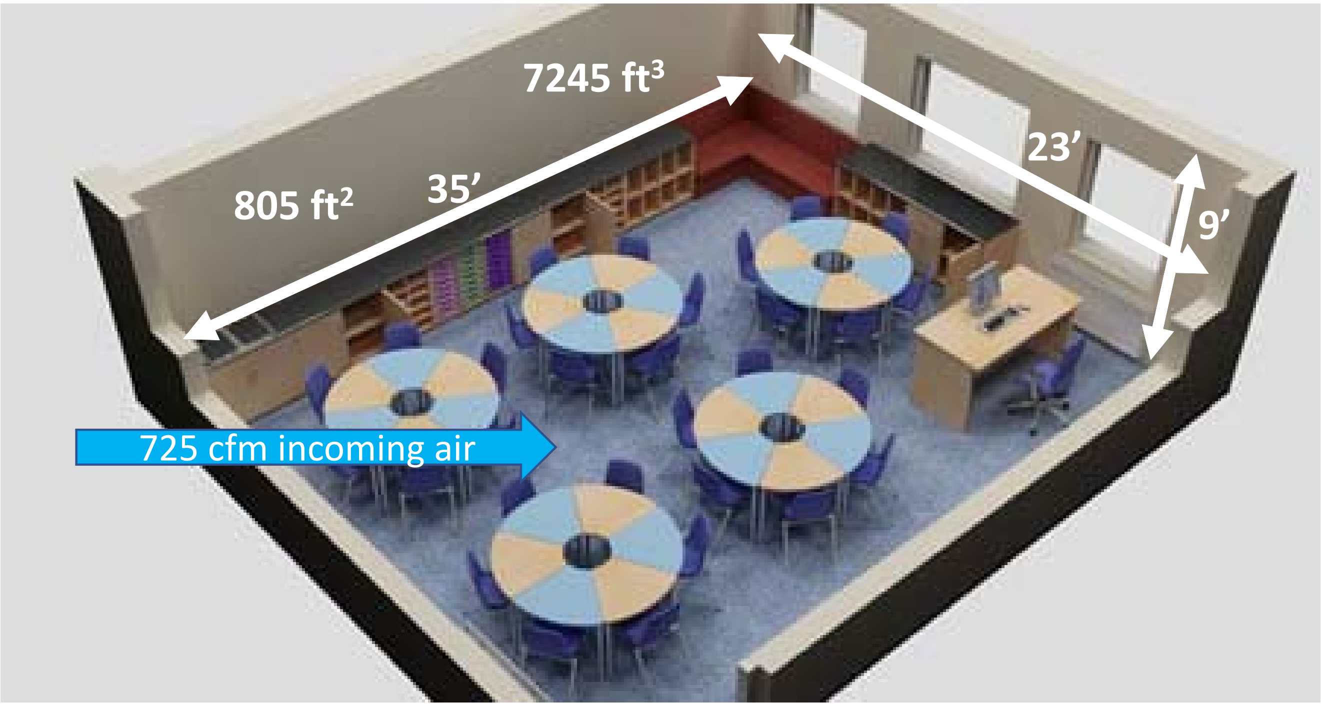
Ventilation assessment criteria

criteria	air exchange rate (in ach)	equivalent CO_2 concentration
pre-pandemic ASHRAE 62.1	2.0-2.6 (15 cfm OA/person)	1100 ppm
pandemic ASHRAE 62.1 & ACGIH (Jun 2021)	**>6-12 ACH "OA and/or sufficiently filtered recirculated air"**	**700 ppm or less**
Harvard (Allen et al., Nov 2020)	3-4 (min); 4-6 (preferred)	4-5 ach ≈ 800 ppm
AIHA (Sept 2020)	6-12 (threshold 4.5)	4.5 ach ≈ 800 ppm 6 ach ≈ 700 ppm
ACGIH (Jun 2021)	same as ASHRAE	700 ppm or less
REHVA (Apr 2021)	5	800 ppm
CDC (latest update: Jun 2021)	-	800 ppm
WHO (Roadmap, Mar 2021)	2.6-3.7 (21 cfm OA/person)	900 ppm

Air changes per hour (ACH)

725 ft^3/min (or **cfm**) or 43,470 ft^3/hr coming into this classroom which has a volume of **7245 ft^3**

- that means the air "turns over" **6 times per hour** (assuming 100% mixing)
- if the air coming into the classroom is 80% (580 cfm) recirculated and **20% outdoor air (or 145 cfm of OA)** then the room is being supplied with **1.2 ACH (OA)**



http://www.blackcherry-design.com/what-we-do/classroom-layouts/

A tool to guide you:

Classroom Ventilation Posting

1a. type of ventilation system

Y	HVAC constant flow		unit ventilator		natural ventilation/hot water/steam radiators

1.b room dimensions

35	length (in feet)	23	width (in feet)	9	height (in feet)
	area (in square feet (ft^2)):	805	volume (in cubic feet (ft^3)):	7245	

1.c room occupancy

35	room maximum capacity	20	room typical capacity	2	select which capacity (1=max, 2=typical)
					6' distancing achievable

2a. room ventilation rate — below ASHRAE 62.1 std

805	HVAC design flow rate (in cfm)	8.1 cfm OA/person		HVAC measured flow rate (in cfm)
20%	proportion outdoor air supply (in %)			
6.7	total air turnovers per hour			
1.3	outdoor air changes per hour (OA ach)			

3. filters

11	MERV rating	date filter was last changed:	can't remember
3.7	equivalent clean air ach		

4. supplementary portable air filters

231	CADR @ top speed (in cfm of cleaned air)	65	dB noise @ top speed
51	CADR @ lowest speed (in cfm of cleaned air)	40	dB noise@ low speed
119	CADR @ typical speed (in cfm of cleaned air)	55	dB noise @ typical speed
1	number of units	3	select speed (1=max, 2=min, 3=typical)
1.0	equivalent clean air ach		background noise somewhat exceeds ASHRAE recommendations

5. supplementary fans

1000	flow rate (in cfm)
RIA	outdoor air (OA) or recirculating indoor air (RIA)
25%	typical % time fan is on when room occupied
0.0	equivalent clean air ach

TOTAL equivalent ACH: 6.1

CO_2 ventilation performance indicator (enter measurement)

peak carbon dioxide (CO_2) concentration (in ppm):

target: >6 to 12 ach
good: 5-6 ach
fair: 4-5 ach
bare minimum: 3-4 ach
poor: <3 ach

no problem:	<600 ppm CO_2
possible problem:	600-800 ppm CO_2
probable problem:	800-1000 ppm CO_2
more outdoor air needed:	1000+ ppm CO_2

Classroom Ventilation Posting

1a. type of ventilation system

	HVAC constant flow		unit ventilator		natural ventilation/hot water/steam radiators

1.b room dimensions

	length (in feet)		width (in feet)		height (in feet)
	area (in square feet (ft^2)):	**0**	**volume (in cubic feet (ft^3)):**	**0**	

1.c room occupancy

	room maximum capacity		room typical capacity		select which capacity (1=max, 2=typical)

this is the easy part:

- you can use a tape measure, or **count ceiling/floor tiles**
- there's **apps** on some cellphones that let you measure the distance
- check the **building layout**/plans/fire exit layout posting (use the drawing scale)
- **no need to be exact**, measuring to the nearest foot will do (area and room volume are automatically calculated)
- enter the **typical and maximum room occupancy** (distancing automatically calculated)

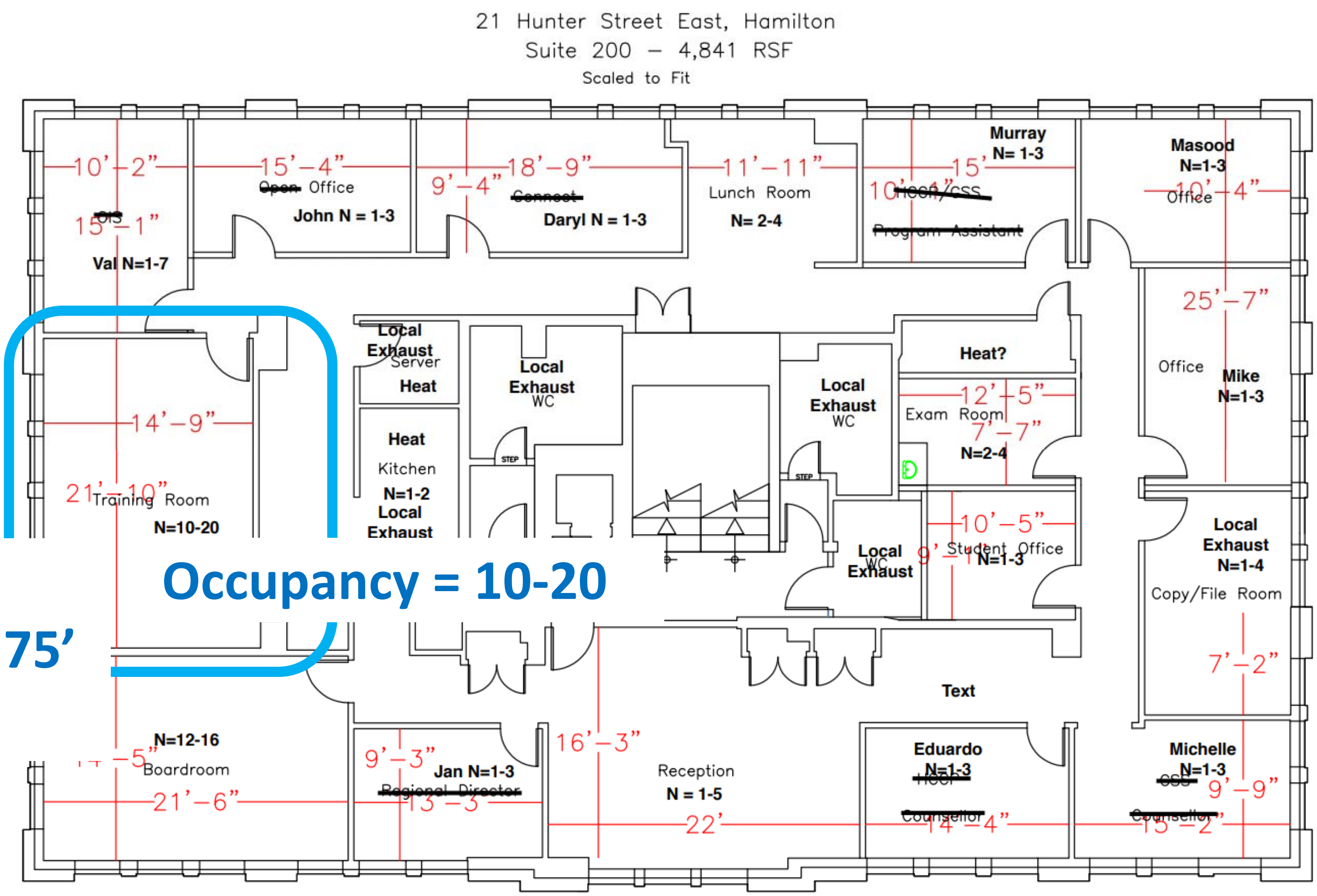
How to tell which type of ventilation system you have:

HVAC ceiling diffuser

HVAC wall diffuser

unit ventilator (fan)

Measuring room size (from drawing):



Room size:
21.83' X 14.75' X 9.00'

Occupancy = 10-20

1a. type of ventilation system

Y	HVAC constant flow		unit ventilator		natural ventilation/hot water/steam radiators

1.b room dimensions

21.8333	length (in feet)	14.75	width (in feet)	9	height (in feet)
	area (in square feet (ft^2)):	**322**	**volume (in cubic feet (ft^3)):**	**2898.4**	

1.c room occupancy

20	room maximum capacity	6	room typical capacity	2	select which capacity (1=max, 2=typical)
				6' distancing achievable	

2a. room ventilation rate **below ASHRAE 62.1 std**

	HVAC design flow rate (in cfm)	**0.0**	cfm OA/person		HVAC measured flow rate (in cfm)
	proportion outdoor air supply (in %)				
0.0	total air turnovers per hour				
0.0	**outdoor air changes per hour (OA ach)**				

this gets a bit tougher:

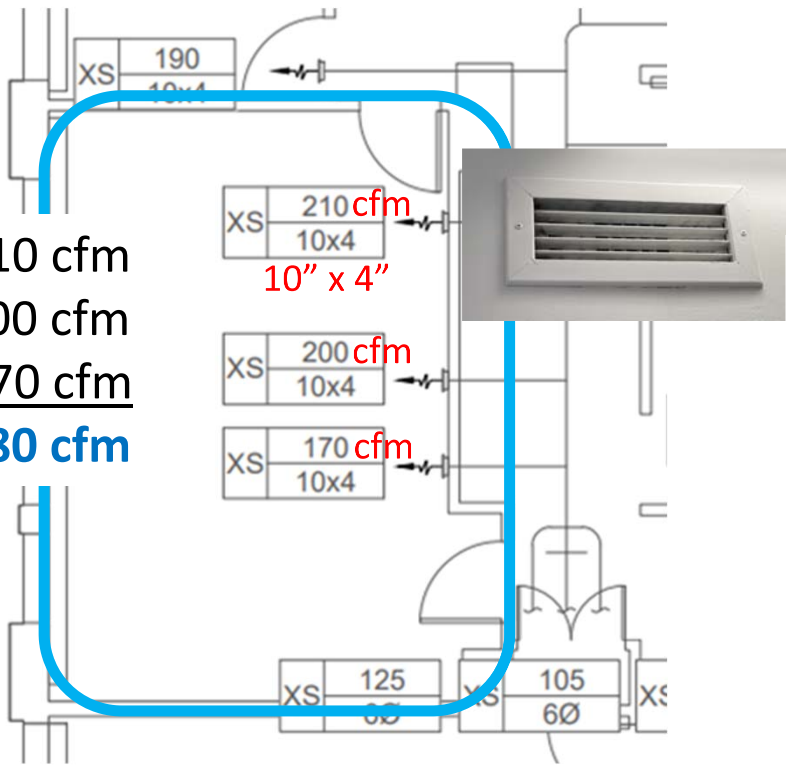
- you probably have to **ask someone** for this information (maintenance/facilities person, JH&S rep,?) – it is usually found on the building drawings (ventilation plans) – *this will be the design flow rate (in cubic feet per minute or cfm)*
- if you have a "ventilation **balancing report**" (if it's old, as long as the system hasn't changed much it should still be relevant) this should give you the *measured flow rate*
- the **proportion of outdoor air (OA) supply** can be fixed at a certain %, but sometimes its variable (then take the maximum and minimum %'s) – again you'll have to ask for it

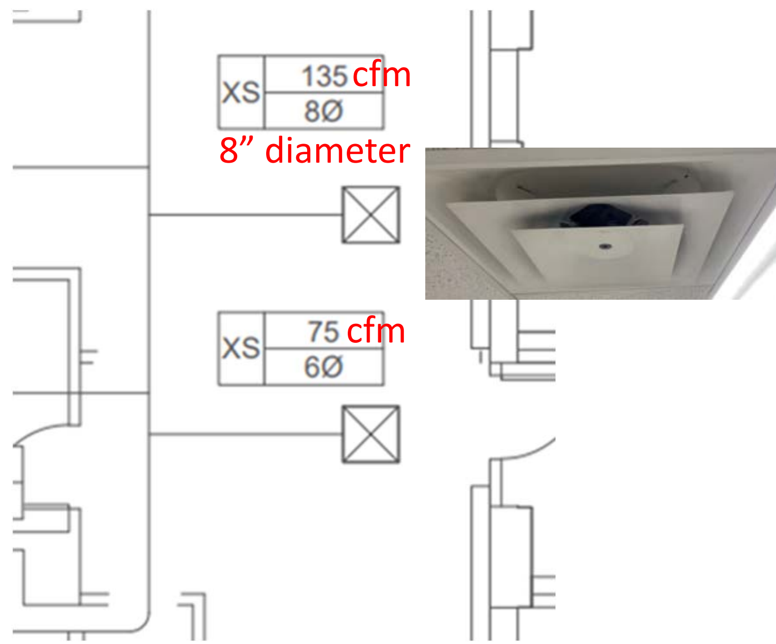
Ways to figure out how much air is coming into your room

1. Ask someone who knows (maintenance/facilities person, JH&S rep,?)
2. Look at the ventilation drawings (the design flow rate)
3. Have someone else measure it (air balancing report)
4. Measure it yourself (class project?)
5. Estimate it from the measured peak carbon dioxide (CO_2) concentration
6. Calculate it from the CO_2 decay curve (another math project?)
7. Estimate based on “rules of thumb”

2. From the ventilation drawings:

210 cfm
200 cfm
<u>+ 170 cfm</u>
580 cfm





2. From the HVAC manual (unit ventilators)

Number One Air Conditioning Maker

Carrier

Division of Carrier Corporation

Carrier Parkway • Syracuse N.Y. 13221

Installation, and Service

Single-Package

SAFETY CONSIDERATIONS

The 50BA,BB Single-Package Cooling Units are designed to provide safe and reliable service when operated within design specifications. However, due to system pressures, electrical components and equipment location, some aspects of installation, start-up and servicing of this equipment can be hazardous.

Only trained, qualified installers and service mechanics should install, start up and service this equipment.

When working on the equipment, observe all precautions on tags or labels attached to the unit, safety notes in the literature and any other safety precautions that apply.

- Follow all safety codes.
- Wear safety glasses and work gloves.
- Use care in handling, rigging and placing bulky equipment.

Table 1 — Physical Data

MODEL 50	BA	BB	BA	BB	BA	BB	BA	BB	BA	BB
	004		006		008		012		016	
OPERATING WEIGHT (lbs)										
Base Unit	390	330	427	360	770	710	950	890	1414	1221
Discharge Plenum	25		25		140		140		140	
OPERATING CHARGE (lbs)	Refrigerant 22									
System 1	3 5	2	4 6	2 5	10	7	10	8	24	15
System 2	—	—	—	—	—	—	—	—	—	—
System 3	—	—	—	—	—	—	—	—	—	—
COMPRESSOR — TYPE 06	Welded Hermetic, 3450 Rpm						Serviceable Hermetic, 1750 Rpm			
System 1	M34	M34	P53	P67	P77	DA818	DB724	DB824	DD337	DD537
System 2	—	—	—	—	—	—	—	—	—	—
System 3	—	—	—	—	—	—	—	—	—	—
No of Unloading Cylinders	0		0		0		2		2	
No of Capacity Steps	1		1		1		2		2	
CONDENSER (BA Only)										
No. . Type	1 TT		1 TT		1 TT		1 TT		1 SC	
INDOOR FAN	Adjustable, Belt-Driven Centrifugal; 1750 Rpm Motor									
Nominal Cfm	1200		2000		3000		4000		6000	
Standard Fan Speed Range (Rpm)	512-782		647-915		495-700		600-850		568-720	
Maximum Allowable Rpm	1100		1100		1100		1100		1100	
No. of Belts . Fan Pulley PD (in)	1 6 4		1 6 4		1 8 5		1 7 0		1 11 4	
Motor Pulley PDR (in)	1 9-2 9		2 4-3 4		2 4-3 4		2 4-3 4		3 7-4 7	
Nom Hp Std...Frame Size	1/3 48		3/4 56		1 56		2 145T		2 145T	
Alt...Frame Size	3/4 56		1 56		2 145T		3 182T		3 182T	
Alt.. Frame Size	—		—		3 182T		—		5 184T	

Ways to figure out how much air is coming into your room

1. Ask someone who knows (maintenance/facilities person, JH&S rep,?)
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3. From the balancing report

AIR OUTLET TEST REPORT

Submitted by Air Audit Inc-Cambridge Ont.

PROJECT: 21 HUNTER STREET - PRELIMINARY AIRFLOW MEASUREMENTS

SYSTEM: HEAT PUMP - WEST

TEST INSTRUMENT: ALNOR RVA 801 & ADM 860 W/FLOWHOOD / AIRFOIL

DATE: JULY 14/2021

AREA	OUTLET DATA				DESIGN		TEST	TEST	TEST	FINAL	
SERVED	#	TYPE	SIZE	AK	VEL	CFM	# 1	# 2	# 3	VEL	CFM
OPEN AREA	1	GRILLE	10 X 4	0.19	NA	NA	1032			[illegible]	196
OFFICE	2	GRILLE	10 X 4	0.19	NA	NA	685			[illegible]	130
OFFICE	3	GRILLE	10 X 4	0.19	NA	NA	[illegible]			[illegible]	129
OFFICE	4	GRILLE	10 X 4	0.19	NA	NA	[illegible]			[illegible]	191
OFFICE	5	GRILLE	10 X 4	0.19	NA	NA	[illegible]			[illegible]	148
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]
STORAGE	7	GRILLE	10 X 4	0.19	NA	NA	[illegible]			[illegible]	208
STORAGE	8	GRILLE	10 X 4	0.19	NA	NA	[illegible]			[illegible]	197
STORAGE	9	GRILLE	10 X 4	0.19	NA	NA	[illegible]			[illegible]	169
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]
OFFICE	11	PIPE	6"	0.20	NA	NA	[illegible]			[illegible]	103
OFFICE	12	PIPE	6"	0.20	NA	NA	[illegible]			[illegible]	141
KITCHENETTE	13	DIFF	1206			NA	[illegible]			[illegible]	219
SERVER RM.	14	DIFF	1206			NA	[illegible]			[illegible]	143

208 cfm
197 cfm
+ 169 cfm
574 cfm

CERTIFIED TEST, ADJUST AND BALANCE REPORT

PREPARED ON: JULY 21/2021 BY:

AIR AUDIT INC. *Since 1987*

110 TURNBULL COURT, UNIT 11 CAMBRIDGE, ONTARIO N1T 1K6

PH(519)740-0871 FAX(519)740-1312

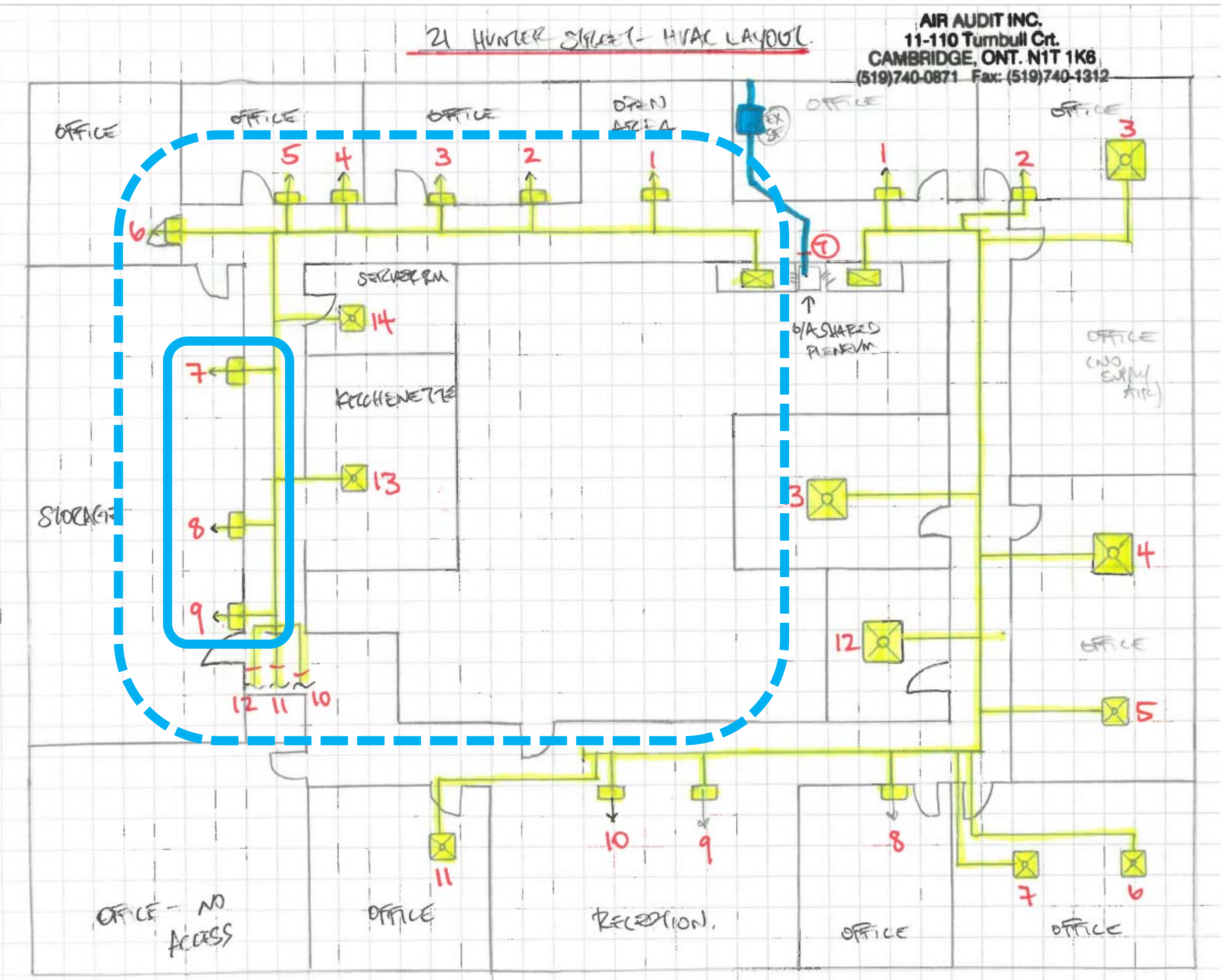
PROJECT: 21 HUNTER STREET

LOCATION: HAMILTON, ONTARIO

MECH. ENGINEER: JOHNSON CONTROLS CANADA LP

CONTENTS: PRELIMINARY AIRFLOW MEASUREMENTS

CERTIFIED MEMBER OF THE NATIONAL ENVIRONMENTAL BALANCING BUREAU NEBB



BACKPRESSURE COMPENSATED
AIR BALANCE SYSTEM

Measuring air flow (the proper way):

thermal anemometer

balometer

4. Measure it yourself:

Ways to figure out how much air is coming into your room

1. Ask someone who knows (maintenance/facilities person, JH&S rep,?)
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4. Measure it yourself:

HOW TO DO THE TEST

Here's how to use the test to measure airflow from a register or exhaust:

1. Tape the mouth of the garbage bag to a bent coat hanger or a homemade ring of cardboard to keep it open (see Figure 1).
2. Crush the bag flat.
3. Place it over the register or exhaust hood (see Figure 2).
4. Count how many seconds it takes for the bag to inflate.
5. Use Table 1 or 2 on the following page to find the airflow from the register or exhaust.

If you want to measure air going out, you can hold an inflated bag against an exhaust grill, and count how many seconds it takes for the bag to deflate. Deflation testing is not as accurate as inflation testing, but it is still a reasonable test. Low airflow is difficult to measure by deflation testing.

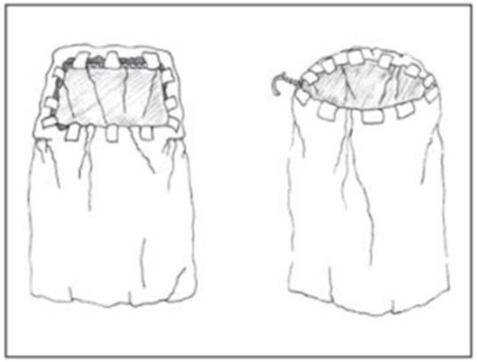


Figure 1 Tape a garbage bag to a ring of cardboard or a bent coat hanger

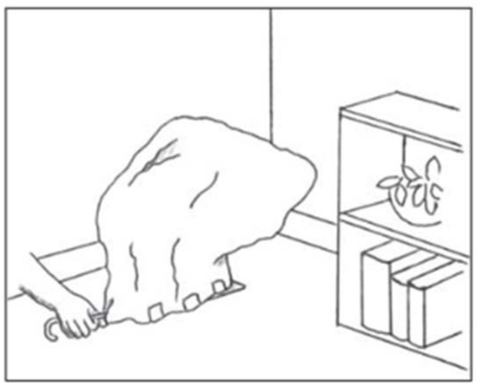
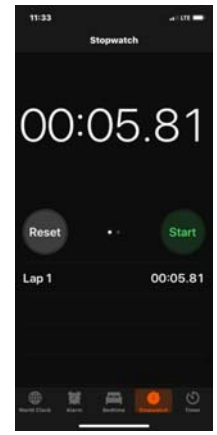


Figure 2 Let the bag inflate over a register



https://publications.gc.ca/collections/collection_2011/schl-cmhc/nh18-24/NH18-24-33-2009-eng.pdf

4. Measure it yourself:

- It takes a bit of practice to get coordinated
- Take at least 3 measurements and make sure they're within the "ball park" of each other (within 10-15% of each other)

Ways to figure out how much air is coming into your room

1. Ask someone who knows (maintenance/facilities person, JH&S rep,?)
2. Look at the ventilation drawings (the design flow rate)
3. Have someone else measure it (air balancing report)
4. Measure it yourself (class project?)
5. Estimate it from the measured peak carbon dioxide (CO_2) concentration
6. Calculate it from the CO_2 decay curve (another math project?)
7. Estimate based on “rules of thumb”

5. Estimate from peak CO_2 measurement:

- It has to be the peak CO_2 measurement (just before lunch hour, at the end of the day)
- Make sure your CO_2 meter is reliable (check to see that outdoor air CO_2 concentration is around 400-450 ppm)
- ASHRAE 62.1-2016 has an **equation** that depends on the occupancy, the % outdoor air and the peak CO_2 concentration
- Outdoor air intake rates are usually between 10-30%

peak CO_2 concentration (in ppm)	**occupancy**	**%outdoor air**	**total airflow estimate**
2700	20	30%	**301 cfm**

Ways to figure out how much air is coming into your room

1. Ask someone who knows (maintenance/facilities person, JH&S rep,?)
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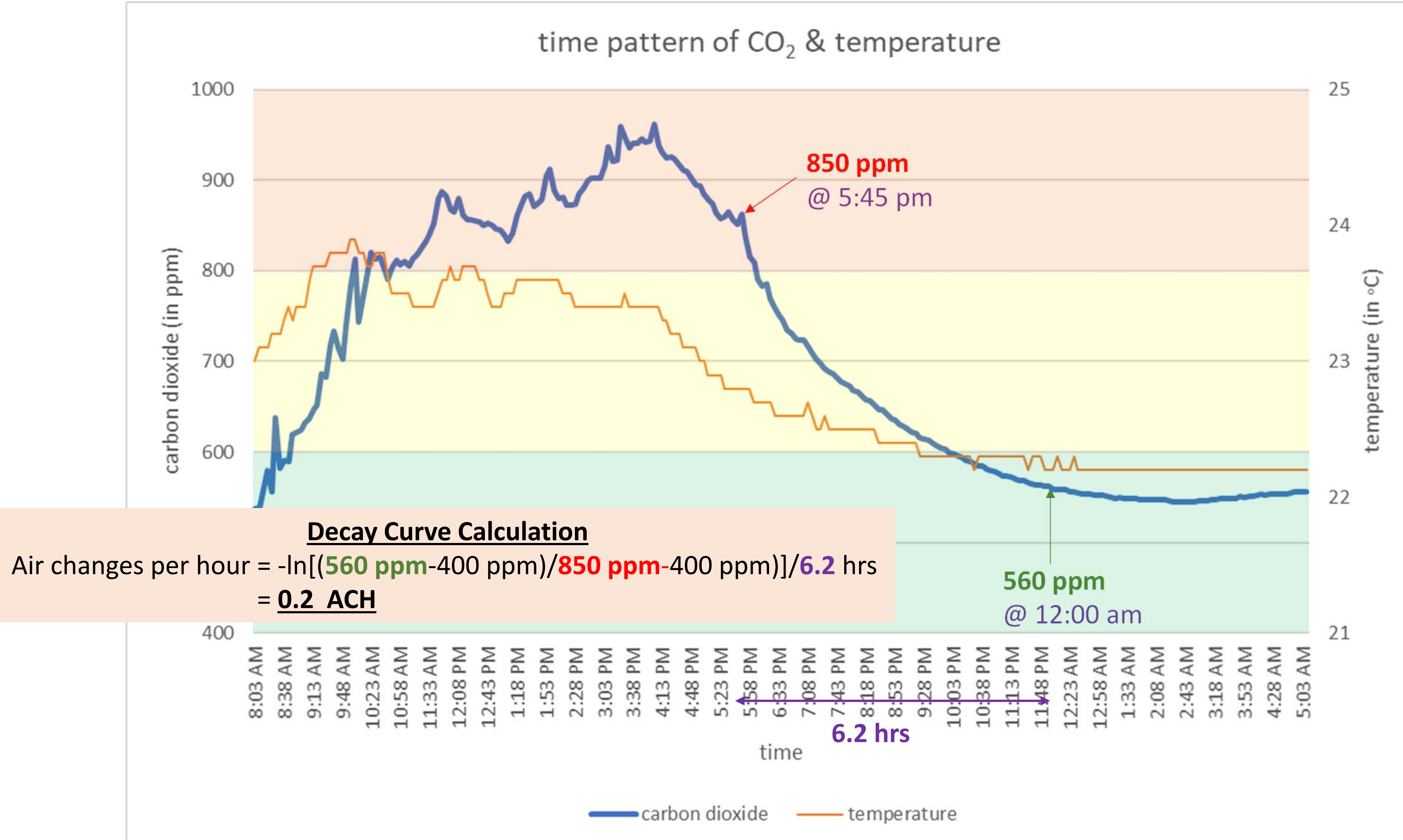
5. Estimate it from the measured peak carbon dioxide (CO_2) concentration
6. Calculate it from the CO_2 decay curve (another math project?)
7. Estimate based on "rules of thumb"

6. Estimate based on CO_2 decay curve:

- You need to data log your CO_2 measurements
- If HVAC system servicing your room is connected to other room, it is best to use the decay at the **end of the day** when the building is empty (but make sure the HVAC is still on)
- The equation calculates the outdoor air (OA) exchange rate NOT the total ventilation rate (i.e., OA + recirculated air), so you need to **back calculate the total ventilation flow rate** based on the OA ach and the % OA being taken into the HVAC system

e.g. in a room with a volume of 2900 ft^3 and a calculated 3.2 OA ach with 20% OA implies a total ventilation flow rate of:

3.2 OA ach x 2900 ft^3 / 20% OA / 60 min/hr = **773 cfm** total air flow rate


time pattern of CO2 & temperature
carbon dioxide (in ppm)
temperature (in °C)
1000
900
800
700
600
400
25
24
23
22
21
850 ppm
@ 5:45 pm
560 ppm
@ 12:00 am
6.2 hrs
time
8:03 AM
8:38 AM
9:13 AM
9:48 AM
10:23 AM
10:58 AM
11:33 AM
12:08 PM
12:43 PM
1:18 PM
1:53 PM
2:28 PM
3:03 PM
3:38 PM
4:13 PM
4:48 PM
5:23 PM
5:58 PM
6:33 PM
7:08 PM
7:43 PM
8:18 PM
8:53 PM
9:28 PM
10:03 PM
10:38 PM
11:13 PM
11:48 PM
12:23 AM
12:58 AM
1:33 AM
2:08 AM
2:43 AM
3:18 AM
3:53 AM
4:28 AM
5:03 AM
carbon dioxide
temperature
Decay Curve Calculation
Air changes per hour = -ln[(560 ppm-400 ppm)/850 ppm-400 ppm)]/6.2 hrs
= 0.2 ACH

Ways to figure out how much air is coming into your room

1. Ask someone who knows (maintenance/facilities person, JH&S rep,?)
2. Look at the ventilation drawings (the design flow rate)
3. Have someone else measure it (air balancing report)
4. Measure it yourself (class project?)
5. Estimate it from the measured peak carbon dioxide (CO_2) concentration
6. Calculate it from the CO_2 decay curve (another math project?)
7. Estimate based on “rules of thumb”

7. Using “rules of thumb”:

- As a last resort you can use the following "rule of thumb": **multiply the area of the room by 1 cfm/ft^2**
- So, if you have a classroom of 800 ft^2 then you can assume the HVAC system is delivering a total of **800 cfm** of airflow

- Another design “rule of thumb” is providing **5-6 air turnovers per hour**
- So, if you 800 ft^2 classroom has a 10’ ceiling then you have a room volume of 8000 ft^3 (ignoring the volume the furniture and people take up) and so 5 to 6 ach implies an airflow rate of:

  5-6 ach * 8000 ft^3 / 60 min/hr = **667-800 cfm**

	area (in square feet (ft^2)):	322	volume (in cubic feet (ft^3)):	2898.4	

1.c room occupancy

20	room maximum capacity	10	room typical capacity	1	select which capacity (1=max, 2=typical)
				6' distancing not achievable	

2a. room ventilation rate

		below ASHRAE 62.1 std			
566	HVAC design flow rate (in cfm)	5.4	cfm OA/person		HVAC measured flow rate (in cfm)
19%	proportion outdoor air supply (in %)				
11.7	total air turnovers per hour				
2.2	outdoor air changes per hour (OA ach)				

3. filters

8	MERV rating	date filter was last changed:	can't remember
1.9	equivalent clean air ach		

this should fairly straight forward:

- you probably have to ask someone for this information (maintenance/facilities person, JH&S rep,?) but they might not give you the **MERV value** (there are other ways of classifying filters)
- if you feel adventurous, ask to have a **look inside the unit** and see how snuggly the filters **fit** into place (they won't work as well if the air leaks around the filters)
- if you have a look inside the HVAC system, **take some pictures** – remember, all the air you breath has to go through this unit (it's the lungs of your building)

Have a look at the filters in use …

https://unitedfilter.com/blogs/news/what-does-merv-rating-mean gaiter mask

cloth mask

N95 respirator

N99 respirator

MERV Rating	Air Filter will trap Air Particles size .3 to 1.0 microns	Air Filter will trap Air Particles size 1.0 to 3.0 microns	Air Filter will trap Air Particles size 3 to 10 microns	Filter Type ~ Removes These Particles
MERV 1	< 20%	< 20%	< 20%	Fiberglass & Aluminum Mesh
MERV 2	< 20%	< 20%	< 20%	~
MERV 3	< 20%	< 20%	< 20%	Pollen, Dust Mites, Spray Paint,
MERV 4	< 20%	< 20%	< 20%	Carpet Fibres
MERV 5	< 20%	< 20%	20% - 34%	Cheap Disposable Filters
MERV 6	< 20%	< 20%	35% - 49%	~
MERV 7	< 20%	< 20%	50% - 69%	Mold Spores, Cooking Dusts,
MERV 8	< 20%	< 20%	70% - 85%	Hair Spray, Furniture Polish
MERV 9	< 20%	Less than 50%	85% or Better	Better Home Box Filters
MERV10	< 20%	50% to 64%	85% or Better	~
MERV 11	< 20%	65% - 79%	85% or Better	Lead Dust, Flour, Auto
MERV 12	< 20%	80% - 90%	90% or Better	Fumes,Welding Fumes
MERV 13	than 75%	90% or Better	90% or Better	Superior Commercial Filters
MERV 14	% - 84%	90% or Better	90% or Better	~
MERV 15	% - 94%	95% or Better	90% or Better	Bacteria, Smoke, Sneezes
MERV 16	95% or Better	95% or Better	90% or Better	
MERV 17	99.97%	99% or Better	99% or Better	HEPA & ULPA
MERV 18	99.997%	99% or Better	99% or Better	~
MERV 19	99.9997%	99% or Better	99% or Better	Viruses, Carbon Dust, <.30 pm
MERV 20	99.99997%	99% or Better	99% or Better	

Illustration Provided by LakeAir / www.lakeair.com

… by the way …

… Nov 12/21 the Public Health Agency of Canada changed their advice on COVID-19 mask use:

What type of mask to choose

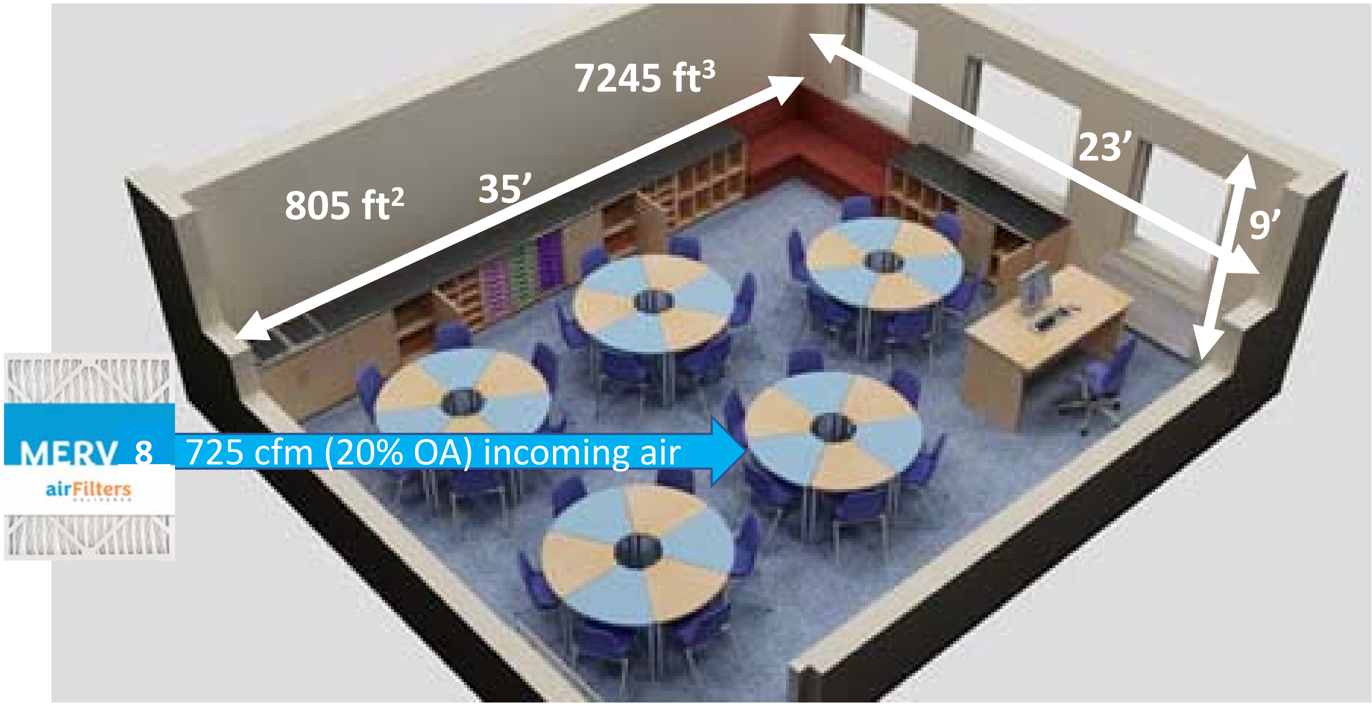
Different types of masks are available for public use. Non-medical masks, medical masks and respirators can all be used in the community. A respirator worn in the community doesn’t need to have been formally fit tested as is required in some occupational settings.

https://www.canada.ca/en/public-health/services/diseases/2019-novel-coronavirus-infection/prevention-risks/about-non-medical-masks-face-coverings.html

Air changes per hour (ACH)

725 cfm coming into this classroom (7245 ft^3) with **20% OA** or **1.2 ACH (OA)**

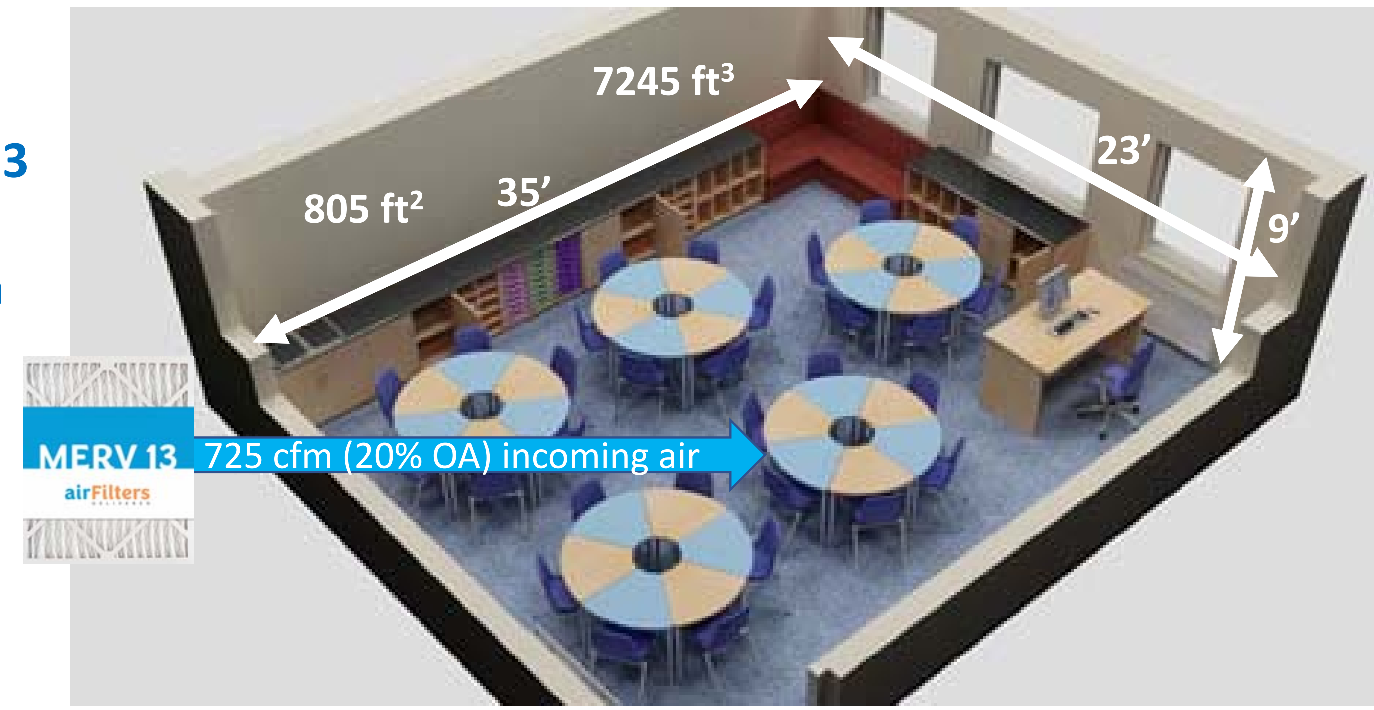
- if the recirculated air is being filtered by **MERV-8** filters (20% efficiency) then we can add **580 cfm recirculated air x 20% = 116 cfm of filtered air** ≈ **1 ACH (OA equivalent)**
- thus we now have the equivalent of **2.2 ACH (OA)**



Air changes per hour (ACH)

725 cfm coming into this classroom (7245 ft^3) with **20% OA** or **1.2 ACH (OA)**

- if the recirculated air is being filtered by **MERV-13 filters** (90% efficiency) then we can add 580 cfm recirculated air x 90% = **522 cfm of filtered air ≈ 4.3 ACH (OA equivalent)**
- thus we now have the equivalent of **5.5 ACH (OA)**



3. filters

13	MERV rating	date filter was last changed:	**can't remember**
8.5	equivalent clean air ach		

4. supplementary portable air filters

	CADR @ top speed (in cfm of cleaned air)		dB noise @ top speed
	CADR @ lowest speed (in cfm of cleaned air)		dB noise@ low speed
	CADR @ typical speed (in cfm of cleaned air)		dB noise @ typical speed
	number of units	1	select speed (1=max, 2=min, 3=typical)
0.0	equivalent clean air ach	**background noise meets ASHRAE recommendations**	

this gets a bit complicated but it's really "**consumer beware**!":

- you need to find the **CADR numbers** which aren't always given – if it's a HEPA system, the CADR number is the safe as the air flow rate (in cfm – be careful, some manufacturers give the flowrates without the filter)
- **different speeds** mean different air flow rates and different noise levels
- **noise level** is important to consider since at top speed, most are too loud for classrooms
- **Don't go for the extras** (e.g., ions, UV, vitamin C!)

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CR Consumer Reports RECOMMENDED

Blue Pure 211+

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Add to cart   C$389.99

Free Shipping | Free 60-day Return | Up To 2-Year Warranty

https://www.blueair.com/us/air-purifiers/blue-pure-211-plus/1695.html

Blueair Air purifiers Filters & Accessories Fan Why Blueair Support Clean Air Community Sign In

Blue Pure 211+

$299.99 Add to cart

Features

Specifications

Dimensions(H x W x D)	20 x 13 x 13 in
Product weight	12.5lbs
Energy consumption	30 - 61 W
Sound level	31 - 56 dB(A)
Air outlet	Top
Air inlet	360°
Recommended room size	540 ft^2
Air changes per hour (ACH)	4.8
Clean air delivery rate (CADR) - Pollen	350 cfm
Clean air delivery rate (CADR) - Dust	350 cfm
Clean air delivery rate (CADR) - Smoke	350 cfm

https://www.blueair.com/us/air-purifiers/blue-pure-211-plus/1695.html

AHAM VERIFIDE Independently Tested. Consumer Trusted.

https://www.ahamdir.com/room-air-cleaners/#

CERTIFIED ROOM AIR CLEANERS

Certified Room Air Cleaners

Compare

FILTER BY

▼ Room Size (Sq Ft)

540

▼ Brand (76)

- [ ] Blue
- [x] Blueair
- [ ] BLUE VENT
- [ ] Braun
- [ ] Braun (Taiwan)
- [ ] Breville
- [ ] cado

show all...

Blueair - 3631101000

Room Size: 550 ft²
Tobacco Smoke CADR: 353
Dust CADR: 347
Pollen CADR: 380
Volts / Frequency: 100V / 50Hz | 240V / (

Show Certificate

Blueair - 605

Room Size: 608 ft²

AHAM VERIFIDE Independently Tested. **Consumer Trusted.**

AIR CLEANER SUGGESTED CLOSED ROOM SIZE

540 SQUARE FEET

CLEAN AIR DELIVERY RATE TESTED

The higher the CADR numbers, the faster the units clean the air

TOBACCO SMOKE	DUST	POLLEN
350	350	350

Blue – Pure Max

Blue by Blueair
Karlavagen 108
Stockholm, 11526 Sweden

Portable air cleaners are most effective in rooms where all doors and windows are closed. Suggested room size is based on 4.8 Air Changes per hour.

www.ahamverifide.org

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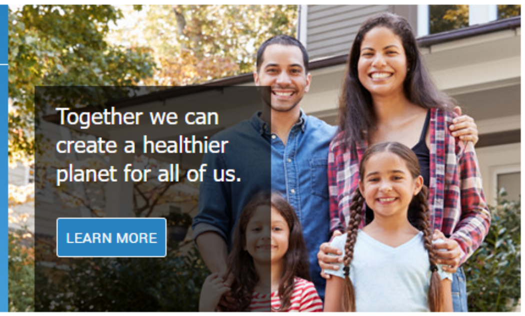

Clean Air Delivery Rate (CADR) is a measure of the amount of contaminant-free air delivered by the room air cleaner. The ENERGY STAR specification requires that manufacturers measure CADR according to AHAM/ANSI AC-1-2002, a test procedure developed by the Association of Home Appliance Manufacturers (AHAM), and recognized by the American National Standards Institute (ANSI). For more information about CADR please visit : www.cadr.org

When considering the purchase of an ENERGY STAR qualified room air cleaner, the comparison should not solely be based on CADR. The CADR of a specific air cleaner model is affected by a number of factors included the size of the model; larger units often have higher CADRs. For more information on the appropriate sized room air cleaner for your application please refer to individual manufacturers' web sites or ask your retailer.

288 Records Found

Filter Your Results

filter by keyword

Brand Name

- AirDoctor (3)
- Airgle (2)
- AIRTHEREAL (1)
- Airvana (2)

Sort by: Smoke CADR/Watt

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ENERGY STAR CERTIFIED

Air Purifiers (Cleaners)

Blueair - 3631101000 : 3631101000

Specifications

ENERGY STAR Unique ID:	2371212
Brand Name:	Blueair
Model Number:	3631101000
Model Name:	3631101000
Annual Energy Use (kWh/year):	209.1979434
Partial On Mode Power (Watts):	0.33
Room Size (sq.ft.):	547
Smoke-Free Clean Air Delivery Rate per Watt:	9.9
Dust-Free Clean Air Delivery Rate per Watt:	9.56
Pollen-Free Clean Air Delivery Rate per Watt:	10.49723757
Smoke-Free Clean Air Delivery Rate (cfm):	353.0
Dust-Free Clean Air Delivery Rate (cfm):	347.0
Pollen-Free Clean Air Delivery Rate (cfm):	380.0
Technology Types:	Fan and Filter
Ozone Emissions (ppb):	1.0
Network Capability:	No
Connected Functions:	No
Filter #1 Type:	HEPA
Date Certified:	2020-12-22
Markets:	United States, Canada
ENERGY STAR Certified:	Yes

Additional Model Information

UPC Codes

Captured On:
11/17/2021

https://m.media-amazon.com/images/I/D1bDWwktsIS.pdf

Specifications[1]

Room size:	50m² (540 sq. ft.)			
Clean Air Delivery Rate (CADR) cfm / m³/h		Smoke 350 / 590	Dust 350 / 590	Pollen 350 / 590
Filter replacement indicator	Yes			
On/Off timer	No			
Speeds	1-2-3-off			
Dimensions	Height: 522 mm (20.5 in) Width: 330 mm (13 in) Depth: 330 mm (13 in) Weight: 7 kg (15 lbs)			
Airflow rate	230 - 620 m³/h (135 - 365 cfm)			
Air exchange[2]	5 per hour (50 m² or 540 sq.ft.room)			
Power usage[4]	30 - 61 W			
Noise level	31 - 56 dB(A)			
Average filter service life	six months[3]			
Warranty	Local regulations			

Blue is available in different colors for the Pure 211+ air purifier unit. The colored fabric works as a pre-filter.

[1]Certified ratings as stated are based on U.S. version models (120VAC, 60Hz) with Blue Particle Filter. Ratings may be affected by use of other Blue filter models.

[2]Air changes per hour are calculated on the recommended room size, assuming 8-foot (2.4-m) ceilings.For smaller rooms, the air changes per hour will increase.

[3]Depending on air quality in the area of use, the recommended six-month filter lifetime may be longer.

[4]The available electrical power voltage and frequency affects the power consumption of the unit. the power consumption might therefore be different from the stated value.

Classroom Ventilation Posting

1a. type of ventilation system

Y	HVAC constant flow		unit ventilator		natural ventilation/hot water/steam radiators

1.b room dimensions

21.8333	length (in feet)	14.75	width (in feet)	9	height (in feet)
	area (in square feet (ft^2)**):**	**322**	**volume (in cubic feet** (ft^3)**):**	**2898.4**	

1.c room occupancy

20	room maximum capacity	10	room typical capacity	1	select which capacity (1=max, 2=typical)

6' distancing not achievable

2a. room ventilation rate

below ASHRAE 62.1 std

566	HVAC design flow rate (in cfm)	5.4	cfm OA/person		HVAC measured flow rate (in cfm)
19%	proportion outdoor air supply (in %)				
11.7	total air turnovers per hour				
2.2	**outdoor air changes per hour (OA ach)**				

3. filters

13	MERV rating	date filter was last changed:	**can't remember**
8.5	**equivalent clean air ach**		

4. supplementary portable air filters

350	CADR @ top speed (in cfm of cleaned air)	56	dB noise @ top speed
130	CADR @ lowest speed (in cfm of cleaned air)	31	dB noise@ low speed
	CADR @ typical speed (in cfm of cleaned air)		dB noise @ typical speed
1	number of units	2	select speed (1=max, 2=min, 3=typical)
2.7	**equivalent clean air ach**		

background noise meets ASHRAE recommendations

Supplementary fans:

- If fans are simply recirculating indoor air, they won't contribute to bringing in outdoor air (in fact, they might blow emissions from one person towards another ☹)
- If a fan is used bring in outdoor air it's a good idea to blow the air out of the room, leaving another opening in the room where the outdoor air can come in, rather than use them to blow air from outside into the room
- The reason is blowing outdoor air into the room may create air currents that flow the emissions from one person to another who is downwind from that source.

Supplementary fans:

- It may be difficult to find the airflow rate from the manufacturer's information (check technical details or operator's manual)

at top speed:

20" box fans can easily move between 1000-2000 cfm

12" fans are about 600-1200 cfm

6" fans are about 250-450 cfm

Classroom Ventilation Posting

1a. type of ventilation system

Y	HVAC constant flow		unit ventilator		natural ventilation/hot water/steam radiators

1.b room dimensions

21.8333	length (in feet)	14.75	width (in feet)	9	height (in feet)
	area (in square feet (ft^2)):	322	**volume (in cubic feet (ft^3)):**	2898.4	

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					6' distancing not achievable

2a. room ventilation rate — **below ASHRAE 62.1 std**

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1	number of units	2	select speed (1=max, 2=min, 3=typical)
2.7	**equivalent clean air ach**		**background noise meets ASHRAE recommendations**

5. supplementary fans

250	flow rate (in cfm)
oa	outdoor air (OA) or recirculating indoor air (RIA)
10%	typical % time fan is on when room occupied
0.5	**equivalent clean air ach**

TOTAL equivalent ACH: **14.0**

CO_2 ventilation performance indicator (enter measurement)

peak carbon dioxide (CO_2) concentration (in ppm): **550**

target: >6 to 12 ach
good: 5-6 ach
fair: 4-5 ach
bare minimum: 3-4 ach
poor: <3 ach

no problem:	**<600 ppm CO_2**
possible problem:	**600-800 ppm CO_2**
probable problem:	**800-1000 ppm CO_2**
more outdoor air needed:	**1000+ ppm CO_2**

Classroom Ventilation Posting

1a. type of ventilation system

Y	HVAC constant flow		unit ventilator		natural ventilation/hot water/steam radiators

1.b room dimensions

21.8333	length (in feet)	14.75	width (in feet)	9	height (in feet)
	area (in square feet (ft^2)):	322	**volume (in cubic feet (ft^3)):**	2898.4	

1.c room occupancy

20	room maximum capacity	10	room typical capacity	1	select which capacity (1=max, 2=typical)
				6' distancing not achievable	

2a. room ventilation rate

below ASHRAE 62.1 std

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2.2	outdoor air changes per hour (OA ach)				

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1	number of units	2	select speed (1=max, 2=min, 3=typical)
2.7	equivalent clean air ach		background noise meets ASHRAE recommendations

5. supplementary fans

250	flow rate (in cfm)
oa	outdoor air (OA) or recirculating indoor air (RIA)
10%	typical % time fan is on when room occupied
0.5	equivalent clean air ach

TOTAL equivalent ACH: 14.0

CO_2 ventilation performance indicator (enter measurement)

peak carbon dioxide (CO_2) concentration (in ppm): 550

target: >6 to 12 ach	
good: 5-6 ach	
fair: 4-5 ach	
bare minimum: 3-4 ach	
poor: <3 ach	

no problem:	<600 ppm CO_2
possible problem:	600-800 ppm CO_2
probable problem:	800-1000 ppm CO_2
more outdoor air needed:	1000+ ppm CO_2

Post it on the door so everyone knows!

… thanks! … any questions/comments?
… then we'll go to our breakout groups

contact: joudyk@ohcow.on.ca