

Building Ventilation In The Age Of Contagions

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Why is Ventilation Suddenly a Problem

- COVID-19 is endemic, it is like tuberculosis, measles, and other airborne contagions from the previous century
- It has been a leading cause of death for 2 years
- To eventually eliminate tuberculosis and other airborne contagions, it took vaccines and modern forced air heat and cooling systems
- Our building ventilation systems have been ignored during the time of great health when our parents and grandparents understood building ventilation

Professor Edward A. Nardell

Harvard Medical School

From Time Magazine: If We're Going to Live With COVID-19, It's Time to Clean Our Indoor Air Properly, Edward A. Nardell is Professor of Global Health and Social Medicine, Harvard Medical School.

- COVID-variants may be with us for years to come, and this will certainly not be the last respiratory virus pandemic. We have long suffered from annual contagious respiratory infections, but exceptionally low rates of influenza and common colds during COVID-precautions have demonstrated that not all of this suffering need happen. So, we need to think clearly and scientifically about how better we can reduce the spread of viruses indoors especially when and where masks will no longer be in common use.
- Are there effective engineering controls that can help make indoor environments truly safer?

A Paradigm Shift to Combat Indoor Respiratory Infection

In May of 2021, 39 scientists published "A Paradigm Shift to Combat Indoor Respiratory Infection"

There is great disparity in the way we think about and address different sources of environmental infection. Governments have for decades promulgated a large amount of legislation and invested heavily in food safety, sanitation, and drinking water for public health purposes. By contrast, airborne pathogens and respiratory infections, whether seasonal influenza or COVID-19, are addressed weakly, if at all, in terms of regulations, standards, and building design and operation, pertaining to the air we breathe.

Ventilation

- Ventilation what is it?
- We hear that we need ventilation in small indoor spaces, But why?
- We hear we need to increase ventilation but what does that mean?

Ventilation what is it?

- It is about Ventilation performance levels
- Ventilation performance is measured as Air Changes Per Hour (ACH)
- ACH is a measure of how often air changes in a room
 - 1 ACH changes the room air 1 time per hour
 - 20 ACH changes the room air 20 times per hour
 - or every 3 minutes (60 min / 3 min = 20 ACH)
- Disease specialists address ventilation only in ACH

ACH = Fan Cubic-feet per Hour / Room Cubic-feet

Ventilation what is it?

- It is not about measuring and maintaining CO2 levels
- Maintaining CO2 levels leads to a system with ACH levels that are too low such as 1 ACH or less
- It is not about Liters/min or cubic-feet/min per person, this will never provide visibility into the actual ACH level in a room and when scenarios are run the ACH levels are too low such as 1 ACH or less
- Ventilation performance when dealing with airborne contagions is always in terms of ACH in a real room setting, not a lab or test fixture

Example: 60 min / air changed every 3 min = 20 ACH

Scenarios Analyzed

- Small indoor space - problem is massive
- Large indoor space - problematic
- Outside - extremely rare
- Mask on / off
- Exposure time of 1, 4 , 8 hours
- Various ventilation rates - key to reduce risk

Scenarios show probability of infection

99% to .0003%

What should be the ACH Level?

- 0 leads to infection
- 1 leads to infection we know from data
- CDC recommends 12 ACH for a hospital room with airborne contagion
- The number must be greater than 1
- As ACH increases the risk of infection drops

What have facility managers done?

- Hawaiian airlines ventilation performance level is 20 ACH and they posted it for all passengers to see on their entertainment screens
- Philadelphia restaurant program is 15 ACH and 106 restaurants participated
- There is a public database with hundreds of facilities showing what they have done

<https://www.cassbeth.com/cleanairbuildings/index.html>

What Must Happen

Facility managers should post their ventilation rates in terms of ACH in all spaces and as a summary for the whole building.

What is the future

- Building codes will change because there will be no choice
- Certificates of occupancy will include ventilation performance levels as ACH

Ventilation Approaches

- Natural
- HVAC – Heating Ventilation & Cooling
- Exhaust Fans
- Ceiling Level UV Lights
- Far UV 222 Lights
- Room sanitizers are too small for most public rooms, may be okay for small 1 person office

What About The Home

- Turn on the HVAC fan when guests arrive and turn it off when they leave

What about costs?

- Typical home fan motor takes the equivalent power of 1 to 3, 100-watt lightbulbs

Commercial Facility Costs

- Must turn on ventilation system 1 hour before and after the public arrives and leaves
- Most commercial facilities are not on demand systems and the fans run all the time, no cost impacts
 - However, there are serious maintenance issues
 - That is why the ACH levels must be determined and posted
- Facilities using on demand systems, some cost impacts
 - They are negligible because the fans take little power once compared to heating and cooling
 - Instead of using the HVAC or exhaust fans they can install ceiling level UV or far UV 222 systems, which will run at about 10% of the mechanical motors

Where do ACH standards and guidelines come from?

- ASHRAE
- CDC
- Department of Defense via DOD standards
- ISO
- Others

Most of the ACH levels are based on comfort except for when airborne contagion mitigation is required in hospitals

ACH Standards & Guidelines

Area	ACH min	ACH max	Source	Area	ACH min	ACH max	Source
Hospital Trauma room	15	-	CDC	Classroom (Art)	16	20	EPA
Hospital room airborne precautions	12	-	CDC	Malls	6	10	EPA
Hospital operating room	25	-		Office	8	30	Greenheck
Hospital rooms	6	10	EPA	Engine Room	20	60	Greenheck
Restaurants	8	12	EPA	Kitchen	12	60	Greenheck
Restaurants	8	20	NCI	Kitchen	7	8	NCI

ACH Standards & Guidelines

Area	ACH min	ACH max	Source	Area	ACH min	ACH max	Source
Restaurants	15	20	wiki	Kitchen	14	18	NCI
Bar	15	30	Greenheck	Kitchens	15	30	EPA
Bar	15	20	NCI	Retail	6	10	NCI, wiki, EPA
Bar	15	20	wiki	Laboratory	12	30	Greenheck
School Classroom	4	12	EPA	Laboratory	6	12	wiki
Auditorium	8	15	EPA	Club Houses	20	30	EPA
Assembly Hall	6	8	EPA	Theatres	8	15	EPA

Commercial Building Challenges

It is more about proper maintenance and operation because this will lead to $ACH = 0$ or $ACH = 1$

- Are vents blocked
- Are dampers partially closed by someone
- Are timers working properly
- Are sensors, fans, and dampers working properly
- Do vents have streamers so people can see system is working

Periodic inspections with documented evidence using certificates that are posted will ensure effective maintenance

Room / Zone Certificate Key Elements

Room / Zone Name:

Square feet:

Cubic feet:

CFM:

ACH Level:

Vents Unblocked: yes/no

Dampers Open: yes/no

Timers Working: yes/no

Inspection Authority and Date:

Comments:

Building Certificate Key Elements

Building Name & Address:

Square feet:

Cubic feet:

CFM:

Min ACH Level:

Max ACH Level:

Average ACH Level:

Inspection Authority and Date:

Comments:

Final Comments

- In the last century, our parents and grandparents had to deal with tuberculosis and other deadly infections
- Vaccines did a great deal to eliminate those contagions, but they would not have worked without the introduction of forced air HVAC systems and ceiling level UV systems
- Unlike in the last century no new technology is needed, we just need to use what our parents and grandparents developed
- There always will be unvaccinated people
- The system solution must use vaccines + ventilation
- The analysis clearly shows why; large numbers of people will continue to get sick and die – see this research findings

Final Comments

It will take years for the building codes to change to include contagion mitigation, so what can we do?

As responsible managers of our children's future

- Stop using my original phrase of increase ventilation
- We must talk in terms of ventilation performance levels using the decades old ACH levels
- We must post ACH levels throughout our buildings

Final Comments

- We are not here to determine the future minimum ACH levels that will become part of future building certificates of occupancy
- We are here to measure and document the building ventilation levels and post the resulting ACH performance levels throughout the building

Some Screen Shots

ACH Calculation Tool

Existing ACH Surveys

clubhouse, house, model, restaurant, school, . for all

Find

bcmc, example, house, etc

Reject

Existing Surveys (select link to load survey)

[Example HOA Clubhouse.txt](#) . [view file](#)

Check and Update the CAB with this data: Go to CAB data [Example HOA Clubhouse](#) .

Facility Data Loaded: Example HOA Clubhouse.txt

Insert Rooms	Room Name (Required Entry)	Room Length (ft-in)	Room Width (ft-in)	Room Height (ft-in)	Vent Length (in)	Vent Width (in)	Vent Air ft/min (vent 1+vent 2+vent n)	Room sq-ft	Room cu-ft	Vent CFM cuft/min	Vent CFH cuft/hr	Num of Vents	ACH	Control Zone #	Vents Clear yes no	System ON yes no fail	eACH UV-C	eACH Far UV	eACH other
0. <input type="checkbox"/>	Ballroom Wall Exhaust	48	32	15	16	16	700+538	1536	23040	2200.8	132048	2	5.7	1A1B	yes	no	12		
1. <input type="checkbox"/>	Ballroom Ceiling Vents	48	32	15	12	5	0+307+298+326+394+365+42	1536	23040	2212.5	132750	12	5.7	1A1B	yes	no	12		
2. <input type="checkbox"/>	Kitchen	16	13	10	9	9	336+346	208	2080	383.6	23016	2	11	1A	yes	no			
3. <input type="checkbox"/>	Library	33	30	10	9	9	400+400+400	990	9900	675	40500	3	4	2					
4. <input type="checkbox"/>	Sitting Room	33	30	15	9	9	400+400+400+400	990	14850	900	54000	4	3.6	2					
5. <input type="checkbox"/>	Conference Room	33	30	10	9	9	400+400+400	990	9900	675	40500	3	4	2					

CAB Entries

0. Space Type	Airport
1. Establishment Name	LAX Los Angeles International Airport
2. Address	
3. City	Los Angeles
4. State / Province	CA
5. Country	USA
6. Date	01/01/2022
7. Data Source	Facility Staff
8. Performed by	External Company UltraViolet Devices Inc, AtmosAir, Genesis Air
9. Company Name Address Contact	
10. Requirement Source	Local Building Code
11. Technology	HVAC System HVAC In Duct UV System Photocatalytic Oxidation, AtmosAir Active bipolar ionization
12. Min ACH	
13. Max ACH	15
14. Avg ACH	10
15. eACH	
16. Filter MERV	13
17. Percent Outside Air	
18. ON and Ventilates Entire Indoor Area	Yes
19. Vent Clearance min 6 ft	Yes
20. No of Rooms	
21. sqft	
22. cuft	
23. No of Buildings	
24. Comments	<p>Heating, air conditioning and circulation systems are regulated by the city of Los Angeles building code. Ultraviolet-C technology from UltraViolet Devices Inc. is used in all terminals to kill microorganisms that cause mold, bacteria and viruses. In Terminal 1, the airport also uses Genesis Air's photocatalytic oxidation process, which captures and destroys airborne particles responsible for poor air quality. AtmosAir's active bipolar ionization system is in Terminal 7. Plans to install the company's ionization tubes and air monitoring technology in the Tom Bradley Terminal Midfield Satellite Concourse, which is nearing completion. When airflow goes over the AtmosAir ionization tube, it</p>

CAB Certificate

Clean Air Building Certificate

Space Type: Clubhouse
Establishment Name: My Building
Address:
City:
State / Province:
Country:
Date:
Data Source:
Performed by:
Company Name Address Contact:
Requirement Source:



Technology:
Min ACH: Max ACH: Avg ACH: eACH:
Filter MERV:
Percent Outside Air:
ON and Ventilates Entire Indoor Area:
Vent Clearance min 6 ft:
No of Rooms: sqft: cuft:

Comments: Example certificate.

In the wake of the COVID-19 disaster many are calling for a paradigm shift in how citizens and government officials think about the quality of the air we breathe indoors. This Clean Air Certificate lets you know that those who operate this building are thinking about the air that we breathe in this building. They have disclosed the ventilation performance of this building so that we all become educated and we never have another indoor infection disaster again.

Serial Number: CAB-367-02132022

Not valid without serial number.

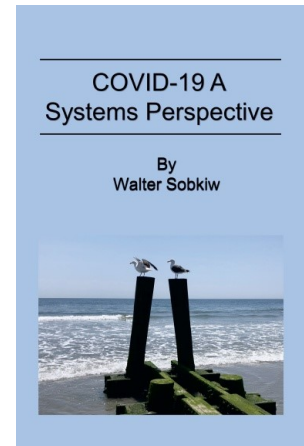
Optional Signature

Date

Links & Contact

COVID-19 Research From A Systems Perspective

- <https://www.cassbeth.com/covid-19/faq.html>
- <https://www.cassbeth.com/cleanairbuildings/index.html>
- <https://www.cassbeth.com/covid-19/index.html>
- walt@cassbeth.com
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Walt's Bio

- Walt changed the dialogue to admit that the COVID-19 virus is airborne, and that ventilation is critical
- Walt collaborated and shared his research with others at Drexel University and the MITRE healthcare coalition starting in 2020
- His research was about determining probability of infection using common operational living scenarios
- He wrote a book: COVID-19 A Systems Perspective