Introduction:context of the webinar

Arnold Janssens – Chair of AIVC WG COVID-19

- Increased evidence that airborne transmission by aerosols plays important role in spreading COVID-19 in indoor spaces
- Many organisations are working on this topic and have produced guidelines:
  - REHVA
  - ASHRAE
  - CIBSE
  - IEQ-GA
  - …
- AIVC-project 'Ventilation, airtightness and COVID-19'
  - Collect, discuss and disseminate information about COVID-19 in relation to ventilation and airtightness
  - Working group defining project deliverables

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AIVC-newsletter, FAQ website

AIVC Newsletter Special Issue COVID-19

Editorial

We hope you are keeping safe and healthy during this challenging period. The COVID-19 pandemic has an unprecedented impact on all of us, both personally and professionally. As researchers and practitioners we also have a role to play in developing solutions to provide healthy indoor spaces to reduce disease transmission, and in informing the public. Based on developing scientific knowledge it has become clear that, although close contact transmission is the dominant transmission route, long-range airborne transmission through small size infected aerosols plays an important role in spreading COVID-19 in indoor spaces. As a consequence, increasing outdoor air change rates, or applying other technical measures to remove infected aerosols are necessary to avoid infection indoors.

The AIVC board decided in their last (online) meeting of September 2020 to start a project to collect, discuss and disseminate information about COVID-19 in relation to ventilation and airtightness. A working group was created to define the activities and outputs of the project with the title "ventilation, airtightness and COVID-19". The working group members are listed at the last page of this newsletter.

This newsletter is a first outcome of the project. It presents a number of questions and answers developed and reviewed by working group members. The collection of relevant questions and the development of clear answers in line with most recent scientific understanding is a continuing process, to which we also invite you, as a reader, to participate. Let us know if you have a question that the working group should look into. This way we hope to expand the FAQ-section, also on the AIVC-website. Many other international organizations in the domain of HVAC, health care or prevention have developed information and guidance documents to support decision makers and public about the COVID-19 pandemic. This newsletter therefore contains an overview of frequently asked questions in relation to COVID-19 and building ventilation, developed by a number of those organizations. The ventilation related guidelines by REHVA and ASHRAE will receive specific attention during the upcoming AIVC webinar, to be held on November 20th, 2020. This webinar is a second outcome of the project, and is announced in more detail in this newsletter and on the AIVC website.

We wish you a pleasant reading and look forward to seeing you in our future events.

Arnold Janssens, chair of AIVC Working Group on COVID-19

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20 November 2020 (16:00-17:30 CET) – AIVC Webinar – COVID-19 Ventilation related guidance by ASHRAE and REHVA

Ventilation is recognized as a major element in strategies for minimizing the risk of COVID infection. REHVA and ASHRAE have developed guidelines, insisting on existing evidence of long-range aerosol-based transmission and emphasizing the importance of ventilation.

The Air Infiltration and Ventilation Centre with support from ASHRAE and REHVA are organizing the webinar "COVID-19 ventilation related guidance by ASHRAE and REHVA" to be held on Friday November 20th, 2020 at 16:00-17:30 (CET).

The webinar will present the COVID-19 related guidelines by REHVA and ASHRAE and will also have a closer look to the similarities and differences in both guidelines.

Presentations and Speakers

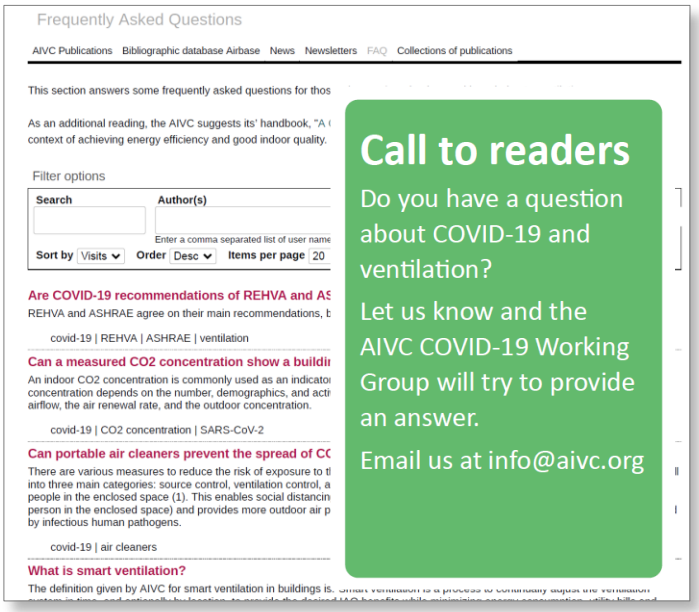
- Introduction, *Arnold Janssens, chair of AIVC WG COVID-19*
- REHVA guidance regarding ventilation, *Jarek. Kurnitski – chair of REHVA COVID-19 task force*
- ASHRAE guidance regarding ventilation, *William P. Bahnfleth, chair of ASHRAE's Epidemic task force*
- Similarities and differences between REHVA's & ASHRAE's guidance, *Valérie Leprince, member AIVC COVID-19 working group & ASHRAE's Epidemic task forces*

Participation to the webinar is FREE but requires you to REGISTER for the event. For further information please visit our website.

Call to readers

The AIVC's COVID-19 Working Group members researched and provided responses to the frequently asked questions (FAQ), in this special issue.

Have a question for the FAQ? Email us at info@aivc.org



Frequently Asked Questions

AIVC Publications | Bibliographic database Airbase | News | Newsletters | FAQ | Collections of publications

This section answers some frequently asked questions for thos

As an additional reading, the AIVC suggests its' handbook, "A (context of achieving energy efficiency and good indoor quality.

Filter options

Search | Author(s)

Enter a comma separated list of user name

Sort by Visits | Order Desc | Items per page 20

Are COVID-19 recommendations of REHVA and AS

REHVA and ASHRAE agree on their main recommendations, b

covid-19 | REHVA | ASHRAE | ventilation

Can a measured CO2 concentration show a buildi

An indoor CO2 concentration is commonly used as an indicato concentration depends on the number, demographics, and acti airflow, the air renewal rate, and the outdoor concentration.

covid-19 | CO2 concentration | SARS-CoV-2

Can portable air cleaners prevent the spread of CO

There are various measures to reduce the risk of exposure to t into three main categories: source control, ventilation control, a people in the enclosed space (1). This enables social distancin person in the enclosed space) and provides more outdoor air p by infectious human pathogens.

covid-19 | air cleaners

What is smart ventilation?

The definition given by AIVC for smart ventilation in buildings is.

Call to readers

Do you have a question about COVID-19 and ventilation?

Let us know and the AIVC COVID-19 Working Group will try to provide an answer.

Email us at info@aivc.org

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IAQ 2020: Indoor Environmental Quality Performance Approaches

Transitioning from IAQ to IEQ

September 13-15, 2021 |
Athens, Greece

New call for abstracts (December 21, 2020):

- Role of ventilation and building airtightness in epidemic preparedness
- Filtration and disinfection options to control COVID19
- Face-covering impacts on indoor air quality
- HVAC and IEQ in a post-COVID world

3

COVID-19 Ventilation related guidance by ASHRAE & REHVA

webinar
2020.11.20

Objectives:

- to present COVID-19 related **guidelines by REHVA and ASHRAE**,
- to understand the **reasons** behind differences,
- to determine **research** needed to move forward

16:00 | **Introduction,** *Arnold Janssens – chair of AIVC WG COVID-19*
16:05 | **REHVA guidance regarding ventilation,**
Jarek Kurnitski – chair of REHVA COVID-19 task force
16:20 | **Questions & Answers**
16:30 | **ASHRAE guidance regarding ventilation,**
William P. Bahnfleth – chair of ASHRAE's Epidemic task force
16:45 | **Questions & Answers**
16:55 | **Similarities and differences between REHVA's & ASHRAE's guidance,**
Valérie Leprince – member AIVC COVID-19 working group& ASHRAE's Epidemic task force
17:05 | **Questions & Answers**
17:15 | **End of webinar**

4

webinar
2020.11.20

COVID-19 Ventilation related guidance by ASHRAE & REHVA: speakers

Jarek Kurnitski – chair of REHVA COVID-19 task force

William P. Bahnfleth – chair of ASHRAE's Epidemic task force

Valérie Leprince – member AIVC COVID-19 working group & ASHRAE's Epidemic task force

Webinar management

Maria Kapsalaki (INIVE, BE)

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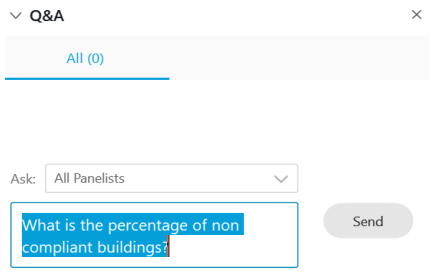
webinar
2020.11.20

How to ask questions during the webinar

Locate the **Q&A box**

Select **All Panelists** | Type your question | Click on Send



Note: Please DO NOT use the chat box to ask your questions!

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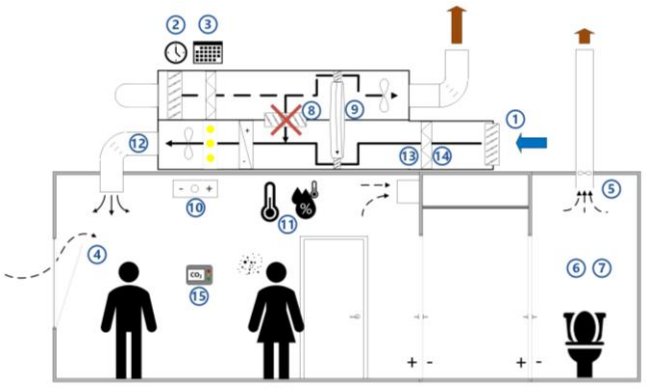
REHVA COVID guidance ver_4

Jarek Kurnitski
Chair REHVA Technology & Research Committee, COVID-19 Task Force

1

15 recommendations for existing buildings

1. Ventilation rates
2. Ventilation operation times
3. Overrule of demand control settings
4. Window opening
5. Toilet ventilation
6. Windows in toilets
7. Flushing toilets
8. Recirculation
9. Heat recovery equipment
10. Fan coils and split units
11. Heating, cooling and possible humidification setpoints
12. Duct cleaning
13. Outdoor air and extract air filters
14. Maintenance works
15. IAQ monitoring



REHVA Federation of European Heating, Ventilation and Air Conditioning Associations

https://www.rehva.eu/activities/covid-19-guidance

2

Longer and continuous ventilation operation

- Extended operation times are recommended: Change the clock times of system timers to start ventilation at nominal speed at least **2 hours before** the building usage time and switch to lower speed **2 hours after** the building usage time
- Do not switch off ventilation at nights and weekends, but operate at lowered speed
- Extended ventilation will remove virus particles from air and also released virus particles from surfaces out the building
- The general advice is to supply as much outside air as reasonably possible. **The key aspect is the amount of fresh air supplied per person**
- Enlarge the spacing among employees (min physical distance 2-3 m between persons) in order to foster the ventilation cleaning effect
- Exhaust ventilation systems of toilets should always be kept on 24/7, and make sure that under-pressure is created, especially to avoid the faecal-oral transmission

Changes in ver_4:

1. **Allow to switch ventilation off during night time and weekends (no evidence against that)**
2. **Toilets exhaust can be operated in the same fashion as main AHUs**

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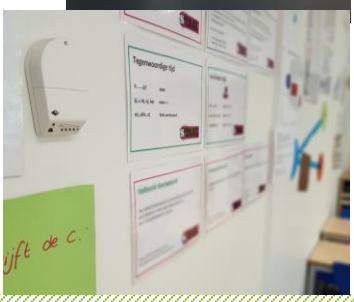
3

What to do if there is no mechanical ventilation?



- In buildings without mechanical ventilation systems, it is recommended to actively use openable windows
- Windows should be opened for 15 min or so when entering the room (especially when the room was occupied by others beforehand)
- Also, in buildings with mechanical ventilation, window opening can be used to boost ventilation further
- **Install CO_2 sensors** at the occupied zone that warn against underventilation especially in spaces that are often used for one hour or more by groups of people, such as classrooms, meeting rooms, restaurants
- Set the yellow/orange light to **800 ppm** and the red light (or alarm) up to **1000 ppm** in order trigger prompt action to achieve sufficient ventilation even in situations with reduced occupancy

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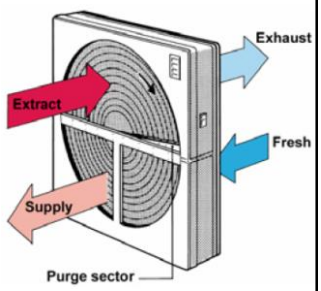
4

Safe use of heat recovery sections

- Heat recovery devices may carry over virus containing aerosols from the exhaust air side to the supply air side via leaks
- In the case of regenerative heat exchangers (rotors) the minimal leakage (seals + carry over) and correct pressure difference between exhaust and supply side are important
- The leakage, carrying over also particles, may increase from the 2% to 20% if fans create higher pressure on the exhaust air side



- Evidence suggest that rotors with adequate purge sector practically do not transfer particles, but the transfer is limited to gaseous pollutants (e.g. smells, tobacco smoke)
- Because the leakage does not depend on the rotation speed, it is not needed to switch rotors off. If needed, the pressure differences can be corrected by dampers or by other arrangements

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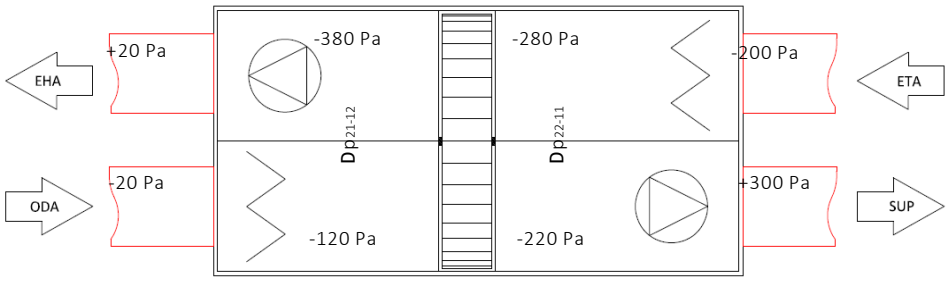
Inspection of rotary heat exchangers to limit internal leakages



Inspecting the heat recovery equipment, including measuring the pressure difference and estimating leakage based on temperature measurement

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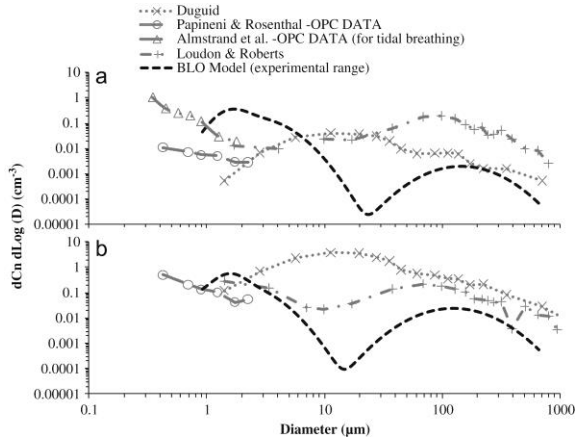
No use of central recirculation

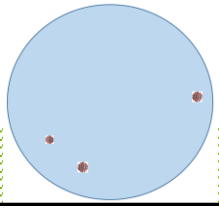
- Virus-containing aerosols in return ducts can also re-enter a building when centralized air handling units are equipped with recirculation sectors (may be in use at least in older all-air heating and cooling systems)
- Recirculation dampers should be closed (via the Building Management System or manually)
- In air systems and air-and-water systems where central recirculation cannot be avoided because of limited cooling or heating capacity, the outdoor air fraction has to be increased as much as possible and additional measures are recommended for return air filtering:
  1. HEPA filters would be needed to completely remove particles and viruses from the return air (usually not easy to install in existing systems)
  2. Alternatively, duct installation of disinfection devices, such as ultraviolet germicidal irradiation (UVGI) also called germicidal ultraviolet (GUV), may be used
  3. **A minimum improvement is the replacement of existing low-efficiency return air filters with ePM1 80% (former F8) filters**

Filtration with ePM1 80% (former F8) filters



Expelled aerosol size distribution (a) speaking and (b) coughing
G.R.Johnson, L.Morawska et al. 2011 https://doi.org/10.1016/j.jaerosci.2011.07.009

- An airborne virus is not naked (0.1 μm) but is contained inside expelled respiratory fluid droplets (= droplet nuclei = virus containing aerosol)
- Most of expelled droplets > 1 μm, main interest range 1-10 μm
- ePM1 (F8) filters provide capture efficiency of 65-90% for PM1
- Therefore, already good fine outdoor air filters provide reasonable filtration efficiency for room or return air



Room level circulation: fan coil, split and induction units

- In rooms with fan coils only or split units (all-water or direct expansion systems), the first priority is to achieve adequate outdoor air ventilation. In such systems, mechanical ventilation is usually independent of the fan coils or split units and two options are possible to achieve ventilation:
  1. Active operation of window opening together with the installation of CO_2 monitors as indicators of outdoor air ventilation;
  2. Installation of a standalone mechanical ventilation system (either local or centralized, according to its technical feasibility)
- Fan coil units have coarse filters that practically do not filter smaller particles but may still collect potentially contaminated particles which may then be released when fans start to operate
- Fan coils only in common spaces are recommended to be continuously operated so that fans of these units will not be switched off but are continuously in operation at low speed

Changes in ver_4:

- **No evidence on the usefulness of the continuous fan operation – to be removed**
- **Add general precaution to avoid high air velocities and especially directed air flows from one person to another**

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Room air cleaners

- Room air cleaners remove particles from the air, which provides a similar effect compared to the outdoor air ventilation
- To be effective, air cleaners need to have HEPA filter efficiency or air cleaners with electrostatic filtration principles (not the same as room ionizers!) often work well too
- To select the right size air cleaner, the airflow capacity of the unit (at an acceptable noise level) has to be at least 2 ACH and will have positive effect until 5 ACH (calculate the airflow rate through the air cleaner in m^3/h by multiplying the room volume by 2 or 5)
- In large spaces, air cleaners need to be placed close to people in a space and should not be placed in the corner and out of sight
- Special UVGI disinfection equipment may be installed in return air ducts in systems with recirculation, or installed in room, to inactivate viruses and bacteria (health care facilities)
- Air cleaners are an easy to apply short term mitigation measure, but in the longer run, ventilation system improvements to achieve adequate outdoor air ventilation rates are needed

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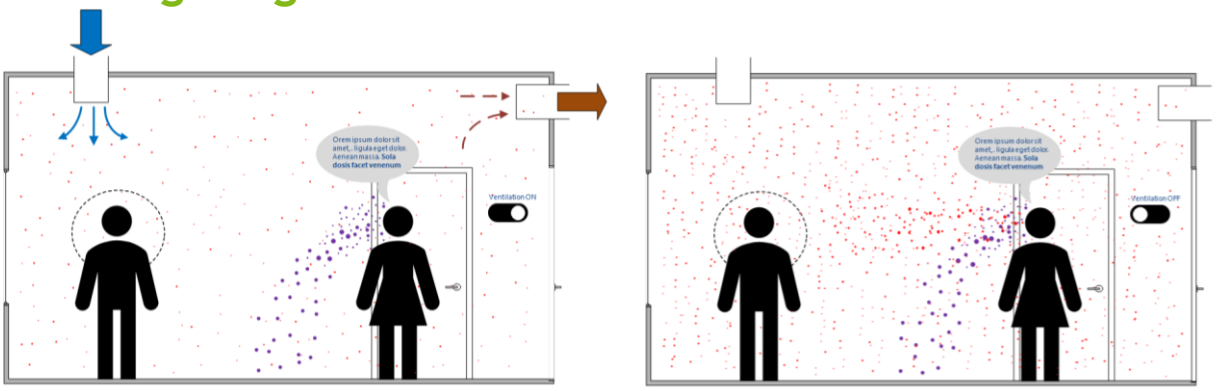
Long range airborne transmission & ventilation



- Exposure = dose (proportional to infection probability) is a product of the breathing rate, concentration and time
- In addition to outdoor air ventilation, virus laden particles can be removed with filtration or deactivated with UVG

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(New appendix in the ver_4 guidance)

11

12

Airborne transmission risk assessment

- COVID-19 disease has been associated with **close proximity** (for which general ventilation isn't the solution) and with spaces that are simply **inadequately ventilated**
- In superspreading events the outdoor air ventilation has been as low as 1–2 L/s per person (Guangzhou restaurant, Skagit Valley)
- Would 10 L/s per person recommended in existing standards be enough – no evidence available
- Some evidence of no cross infections from hospitals (about 40 L/s per patient, 6-12 ACH)

- Typical sizing according to ISO 17772-1:2017 and EN 16798-1:2019 results in default Indoor Climate Category II to 1.5 – 2 L/s per floor m^2 (10–15 L/s per person) outdoor airflow rates in offices and to about 4 L/s per floor m^2 (8–10 L/s per person) in meeting rooms and classrooms
- 4 L/s per floor m^2 in meeting rooms and classrooms corresponds to 5 ACH
- WHO 6 ACH https://www.youtube.com/watch?v=XJC1f7F4qtc&feature=youtu.be

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(New appendix in the ver_4 guidance)

12

Standard airborne disease transmission Wells-Riley model application

- Common cold/rhinovirus (Yuexia Sun et al. 2011) 1-10 quanta/h
- Influenza (Mesquita, Noakes and Milton 2020) 0.1-0.2 q/h in average, but 630 q/h max daily rate
- SARS-CoV-2 (Buonanno G, Morawska L, Stabile L, 2020):

Activity	Quanta emission rate, quanta/h
Resting, oral breathing	3.1
Heavy activity, oral breathing	21
Light activity, speaking	42
Light activity, singing (or loudly speaking)	270

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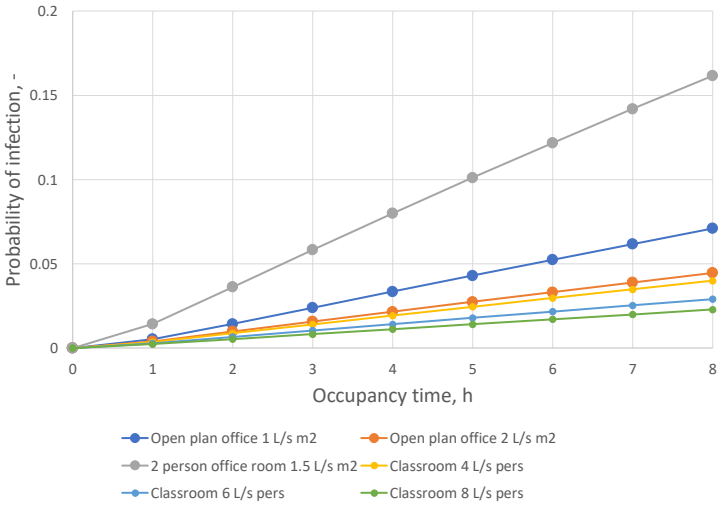
(New appendix in the ver_4 guidance)

Airborne transmission risk assessment added

- Assumption of 1 infected person in all rooms
- 5 quanta/h for office work and classroom occupancy (applies for SARS-CoV-2 and common cold)
- Full mixing assumed
- 1.5 L/s per m^2 ventilation rate in 2 person office room of 16 m^2
- 50 m^2 open plan office and 56 m^2 classroom
- → **Both the ventilation rate and room size matter, resulting in the total airflow rate per infected person**



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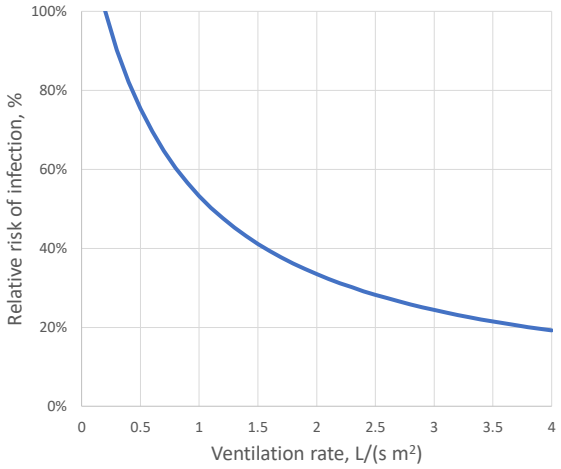
(New appendix in the ver_4 guidance)

Converting results to relative risk

- Open plan office with 2 L/s per person (0.2 L/s per m^2) with occupant density of 10 m^2 per person considered as 100% relative risk level
- This ventilation rate that is a half of an absolute minimum of 4 L/s per person can be used to describe superspreading events
- Category II ventilation rate (10 m^2 per person occupant density, low polluting) 1.4 L/s per m^2 results in 43% relative risk and Category I ventilation 2.0 L/s per m^2 in 34%



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(New appendix in the ver_4 guidance)

Conclusions

- While there are many possibilities to improve ventilation solutions in future, it is important to recognize that current technology and knowledge already allows the use of many rooms in buildings during a COVID-19 type of outbreak as long as ventilation rates correspond to or ideally exceed existing standards
- Regarding the airflow rates, more ventilation is always better, but to dilute the aerosol concentration the **total airflow rate in L/s per infected person matters**
- Large spaces ventilated according to current standards are reasonably safe, but smaller rooms occupied by fewer people pose a higher risk even if well ventilated
- Limiting the number of occupants in small rooms, reducing occupancy time and applying physical distancing will in most cases keep the probability of cross-infection to a reasonable level
- For future buildings and improvements, Category I ventilation rates can be recommended as these provide significant risk reduction compared to common Category II airflow rates

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AIVC Webinar, 11/20/2020
COVID-19 Ventilation Related Guidance by ASHRAE and REHVA

ASHRAE's Ventilation Recommendations for COVID-19 Risk Mitigation

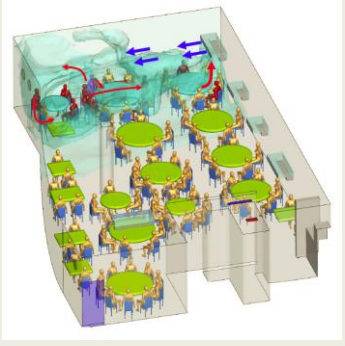
William P. Bahnfleth, PhD, PE, FASHRAE, FASME, FISIAQ
Professor, The Pennsylvania State University, USA
Chair, ASHRAE Epidemic Task Force

ASHRAE
PennState College of Engineering
ARCHITECTURAL ENGINEERING

1

Covid-19 Transmission Characteristics

- Covid-19 transmission
  - *Can be transmitted by airborne route indoors*
  - *Super-spreading incidents with observed or suspected low outdoor air exchange rates*
  - *Evidence of impact on transmission by in-room recirculation when outdoor air exchange is inadequate*
  - *No clear evidence of room to room transmission through ventilation systems (system level recirculation)*



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Scope of ASHRAE Guidance

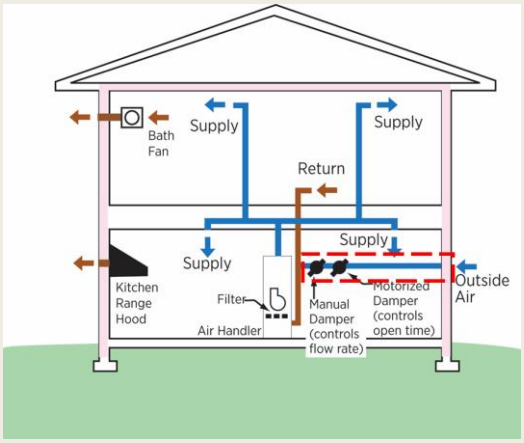
(Some still under development)

- Residential (Detached, Multi-unit)
- Commercial/Retail
- Schools (K-12, Universities)
- Communities of Faith
- Laboratories
- Healthcare (Hospitals/Clinics, Alternate Care Facilities, Nursing homes)
- Transportation

- Intended to be adaptable to any system type
- Not climate zone-specific
  - *Members in more than 130 countries*
  - *More than 20% of members outside North America*
  - *US includes 8 of 9 climate zones*

Typical Residential Forced Air System

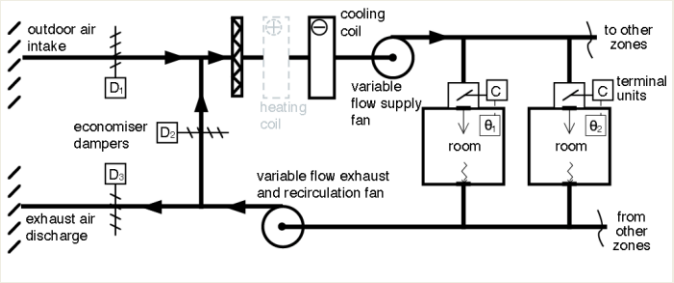
- Constant volume recirculating system
- Furnace/DX air conditioner or heat pump
- Older homes likely to have no outdoor air supply
- Newer homes may have energy recovery ventilators



https://www.energy.gov/eere/buildings/downloads/building-america-top-innovations-hall-fame-profile-low-cost-ventilation

Typical Variable Air Volume (VAV) System

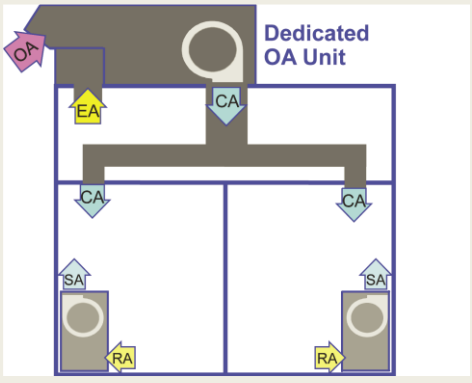
- Most air supply is recirculated
- Economizer controls permit up to 100% outdoor air to save energy
- Maximum possible outdoor air depends on weather
- Filters normally located in central supply air path
- More outdoor air → less recirculation through filters



https://www.cibsejournal.com/cpd/modules/2019-04-vav/

Typical Dedicated Outdoor Air (DOAS) System

- 100% outdoor air system with energy recovery
- Normally sized for no more than ventilation requirement
- Limited or no ability to increase outdoor air flow rate
- Often serve spaces without operable windows.
- Filters in DOAS do not clean indoor air



Core Principles for Ventilation and Air Distribution

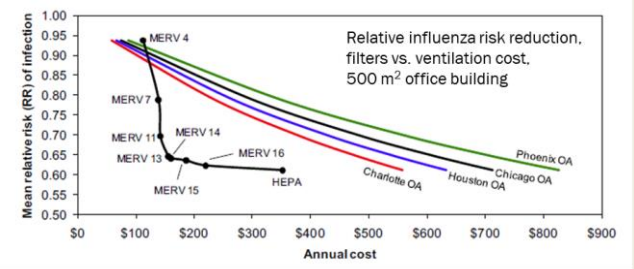
- Provide a*t least* design minimum outdoor air when building is occupied (e.g., compliant with ASHRAE Standard 62.1)
- Provide filter and air cleaner performance equivalent to *at least* MERV 13 (~ePM1 50%) for recirculated air streams (MERV 13 filters if possible)
- Operate system for a time required to achieve three equivalent air changes of outdoor air before first daily occupancy and between occupied periods, if needed
- Prefer mixing without strong air currents that could increase direct person to person transmission
- Use combinations of outdoor air, filters, and air cleaners that provide desired exposure control while minimizing energy penalties

Why minimum required outdoor air and not as much as possible?

- Minimum outdoor air *by itself* is not sufficient, but “as much has possible” has inconsistent, sometimes adverse consequences
  - *DOAS – does not change operation or reduce risk*
  - *VAV or other all-air system*
    - Possibly large risk reduction
    - Large energy use increase
    - Potential operational problems
    - Reduces filter effectiveness
- Minimum outdoor air + upgraded filters can achieve similar outcome with lower energy use and cost

Why MERV 13 filters and not HEPA for HVAC equipment?

- Existing air handling units and some terminal units *may* accept MERV 13, but definitely not HEPA
- Lack of room to room transmission suggests near 100% single pass efficiency is not essential
- Removal rate and not single pass efficiency is most important – high flow with moderate efficiency



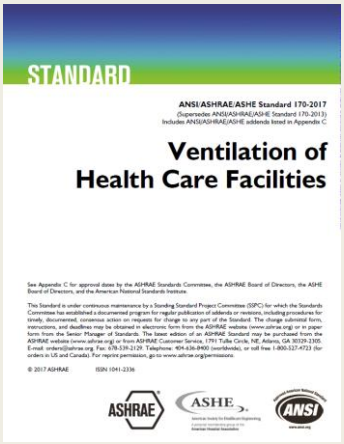
Azimi and Stephens, Building and Environment 70 (2013) 150-160

Why is recirculation not a concern?

- It ***is*** a concern within spaces when there is poor ventilation and filtration
- It ***is*** a concern for energy wheels, which should be checked
- Within systems, lack of space-to-space infection transmission evidence suggests dilution makes risk low
- Eliminating recirculation in all-air systems like typical VAV trades off with central filtration performance
- High recirculation rates through efficient filters is the basic approach to infection control in healthcare facilities

ASHRAE Standard 170-2017 Infection control is an objective

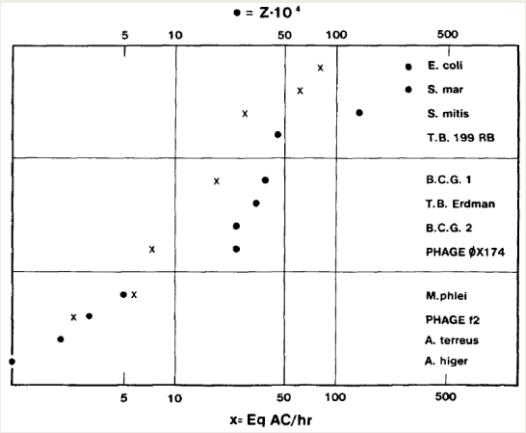
- Patient room minimum, requirements
  - *Outdoor air: 2 ACH*
  - *Total supply air: 4 ACH*
  - *Pre-filter: MERV 7*
  - *Final filter: MERV 14*
  - *Exhaust all room air outdoors - no*
- Protective environment
  - *Outdoor air: 2 ACH*
  - *Total supply air: 12 ACH*
  - *Pre-filter: MERV 7*
  - *Final filter: HEPA*
  - *Exhaust all room air outdoors - yes*



What is the role of air cleaners?

- Supplement outdoor air and mechanical filtration to achieve exposure targets
- May be central or in-room
- Recommended
  - *Standalone HEPA filtration*
  - *Germicidal ultraviolet*
    - Upper room most effective
    - Air-handler/in-duct may be lower cost, but less effective
- Others
  - *Mostly technologies that produce reactive species*
  - *Caveat emptor!*

Upper Room UVGI Equivalent Air Changes



Riley, R. and Nardell, E., 1989. Clearing the air. *Am Rev Respir Dis*, *139*, pp.1286-94.

Why prefer mixing when stratification is "known" to give better IAQ?

"…the general air distribution system in many cases creates a fully mixed concentration, which to some extent protects people from a high exposure from the source person."

Nielsen, P., et al. 2008. ASHRAE Transactions 114: 632.

"Based on the available data and our understanding at present, … we do not recommend the use of displacement ventilation…for control of exhaled substances or any harmful infectious aerosols."

Li, Y, et al. 2011 *ASHRAE Journal*, *53*(6), pp.86-89.

In most existing buildings, revision of air distribution in the short term is not an option

What is "desired exposure control"

- Targets for exposure control
  - *Growing acceptance and use of "equivalent clean air supply" approaches to Covid-19 risk management*
  - *Typically based on Wells-Riley model analysis*
  - *ASHRAE has not made recommendations, but others have*
  - *Multiple risk estimating tools are available*
- This approach allows optimization of with respect to cost and operational constraints
- Results are somewhat comparable to healthcare ventilation requirements

Summary

- ASHRAE recommendations provide a minimum baseline that may require supplementation
- Emphasis is on feasibility of implementation with some consideration for energy use
- Allowance of multiple controls and use of equivalent clean air approach allows owner/operator to tailor effective strategies to local conditions
- Better understanding of total air exchange requirements is needed

Thank you!

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ASHRAE Covid-19 resources
ashrae.org/covid19

ASHRAE

PennState College of Engineering | ARCHITECTURAL ENGINEERING

Similarities and differences between REHVA's & ASHRAE's guidance

VALÉRIE LEPRINCE – INIVE

AIVC WEBINAR NOVEMBER 20TH, 2020

1

Objectives of this presentation

- Point out differences between REHVA and ASHRAE recommendations
- Discuss research/standards needed to move forward and provide answers
- Explain reasons behind those differences
- Not try to find out "who is right and who wrong?"

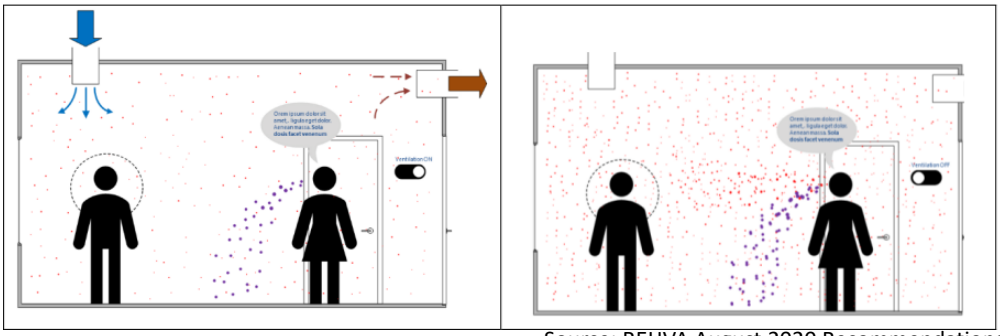
Focus on non-residential buildings

2

Similarities: agree on the risk of airborne transmission

An infected person leads to aerosol exposure in the breathing zone of another person.

When the room is ventilated with a mixing ventilation system, **the amount of virus-laden particles in the breathing zone is lower** than when the ventilation system is off.



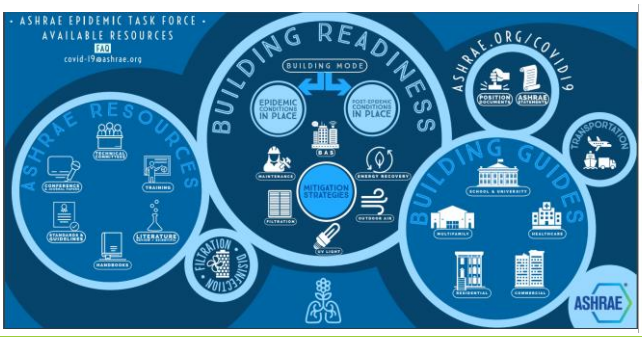
Source: REHVA August 2020 Recommendations

3

Different scope

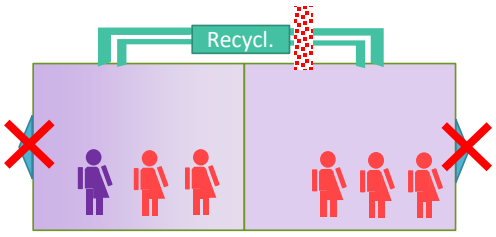
REHVA guidance covers commercial and public buildings (no residential buildings)

ASHRAE has various guidance documents adapted to different kinds of buildings (inc. healthcare and transportation)



4

What we do not want is:



Infected person

No/little air renewal

Recycl. Recycling between zones with only large particle filters

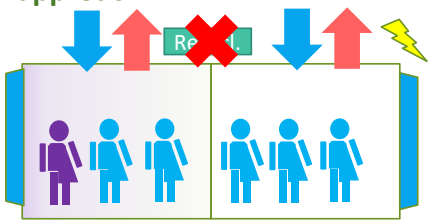
of infected aerosols

=> People breathing air with high concentration of infected aerosols all over the building

5

But what do we prefer?

REHVA approach



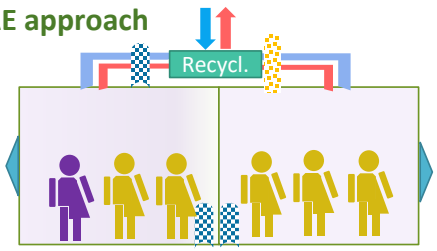
Higher air renewal

No recirculation

More energy use

People subject to thermal stress (but not to infected aerosols)

ASHRAE approach



Recycl. Recycling with MERV 13 / ePM1 50% filters, maximum flowrate

Standard air-renewal

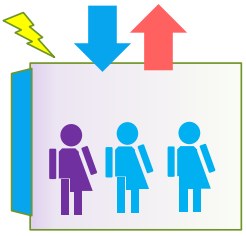
Air cleaner/disinfection (UVGI)

People subject to a low concentration of infected aerosols

6

How much ventilation flowrate have to be increased?

REHVA approach

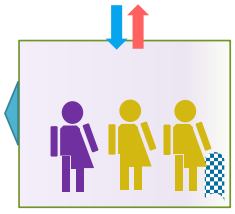


REHVA recommends to supply as much outdoor air as reasonably possible and **use openable windows** much more than normal **even if this causes thermal discomfort** (for buildings without mechanical ventilation).

Agreement on:

- The DCV system shall be overruled
- Rooms shall be flushed before and after occupancy

ASHRAE approach



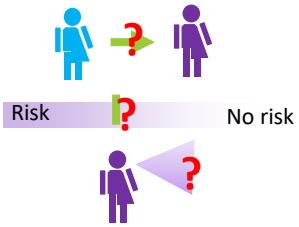
ASHRAE warns against causing a thermal stress and lowering resistance to infections and estimates that **other methods should be considered first** when the energy/comfort/IAQ conditions warrant.

Ventilation may be increased above minimum required by standards if deemed necessary

What do we need to agree on that?

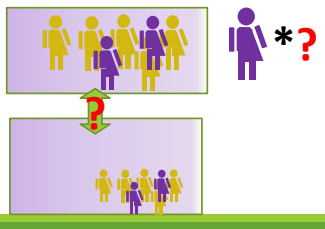
Is **thermal stress** an issue:

- Does it enhance the risk to develop the COVID?
- Does it increase the risk to develop a severe form of COVID?



Multiple information to determine the **needed ventilation flowrate**

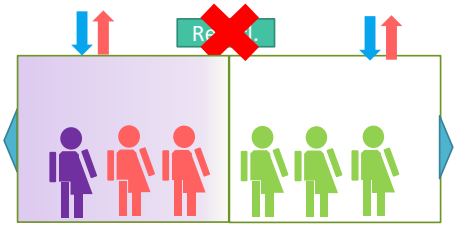
- From what concentration/time the exposure to infected aerosols becomes risky?
- What is the emission of infected aerosols per sick-person?
- What is the foreseen percentage of sick-persons in a room?
- Shall only the number of persons be taken into account to estimate the required flowrate or also the volume?
  - How is the air mixed, is the concentration homogeneous or not?



Can air-cleaning replace part of outdoor air in COVID context?

Regarding recirculation

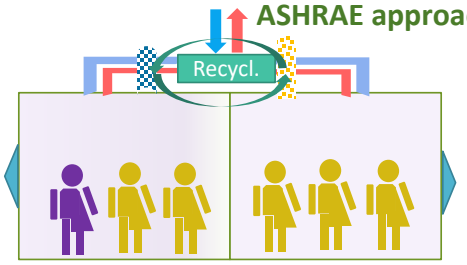
REHVA approach



REHVA recommends to close recirculation dampers even if they have air filters.

For a given flowrate the impact of switching off the recirculation is increasing the concentration in the room of the infected person but no spreading in other spaces.

ASHRAE approach



ASHRAE recommends

- **upgrading recirculation filters to MERV 13**
- **A maximum flow** through the filter to remove as many infected aerosols as possible.

In general, ASHRAE believes that dilution, filtration and disinfection all act together and that in many circumstances filtration can be superior to increased ventilation.

9

What do we need to agree on that?

Previous information on emission, risky concentration, etc.

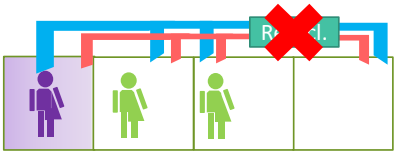
For how long does the virus survive in a ventilation system?

Probably the recirculation recommendation shall be different according to:

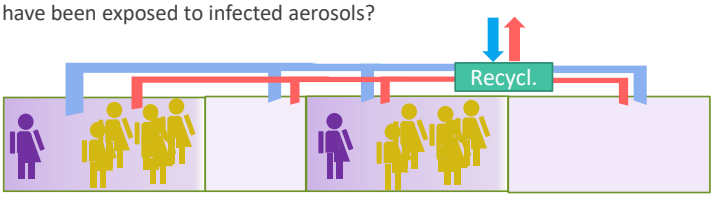
- The building occupation (all room with the same density or not)
- The occupants: high-risk individuals or not.
- The number of persons that may be infected

⇒ **Interpretation of guidance by competent professionals is important**

Is there a need to track people that may have been exposed to infected aerosols?



Hotel/Healthcare rooms



School

10

Regarding the efficiency of filters to inactivate the virus

REHVA approach:
HEPA or ePM1 80 % filters

- Catch almost 100% of the infected aerosols
- High resistance, may be incompatible with existing systems and with higher flowrates

ASHRAE approach:
MERV 13 filters

- Low resistance:
  - Compatible with most existing systems
  - Allow to pass large flowrate through
- Won't catch 100% of the infected aerosols

If recirculation cannot be avoided: installation of HEPA filters or at least ePM1 80% filter

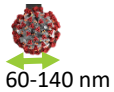
UVGI "may be used"

ASHRAE estimates that MERV 13 filters are sufficient to catch infected aerosols, and estimates that high air-change rates through moderately high-efficiency filters do help.

Ultraviolet Germicidal Irradiation (UVGI) technologies are recommended

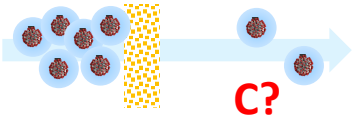
What do we need to agree on that?

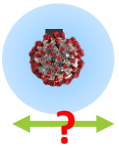
The virus has a diameter between 60-140 nm which is not catchable by a MERV13 filter but it is not about catching "naked" viruses but about catching the aerosols that contain infectious viruses.



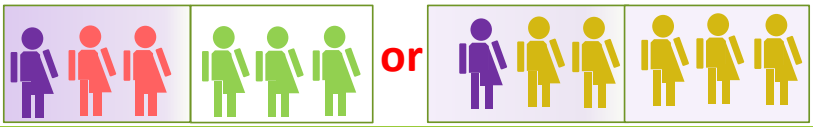
We need measurements of the efficiency of MERV13 filters on infected aerosols

- Measurement for a new filter
- Measurement **after discharge** of the filter



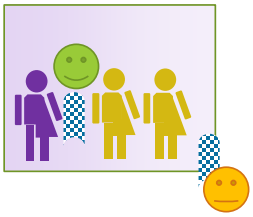


Again in which cases is it better to have a smaller concentration everywhere or to preserve safe-zones?



How should portable air-cleaning devices be used?

REHVA approach



Air- cleaner

HEPA filters

Other filters

REHVA implies it is mostly effective if located in the breathing zone.

REHVA only recommends air cleaners with HEPA filters efficiency and says that UVGI may be installed in return air ducts in systems with recirculation or in rooms provided that they are correctly sized, installed and maintained.

ASHRAE approach

Check CADR* instead of filters performance only

ASHRAE estimates that UVGI upper room systems are more effective than in-duct in terms of CADR (Clean Air Delivery Rate) but are only suitable in some spaces.

*See IEC 63086-1 test method

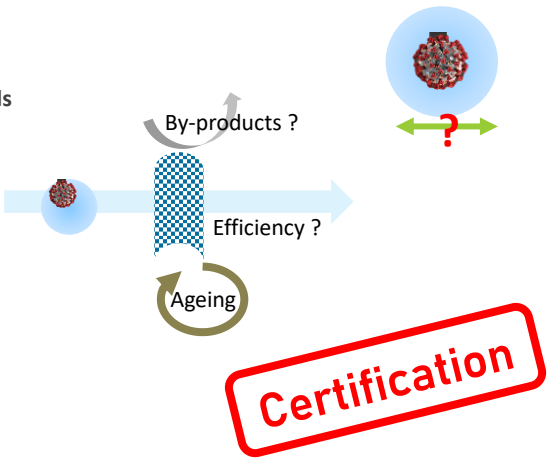
What do we need to agree on that?

Size of infected aerosols

Independent research on

- **Long-term** efficiency of air-cleaners on **infected aerosols**
  - According to their technologies
- **By-products** generated by air-cleaners

Certification of air-cleaners products.



Is CO_2 a good indicator to stress the need to ventilate in the context of COVID?

REHVA

The source of CO_2 and COVID infected aerosols is the same => people
The more CO_2, the more risk of a high concentration of infected aerosols

REHVA recommends 800 ppm CO_2 (absolute value) as a proxy of good ventilation.

ASHRAE

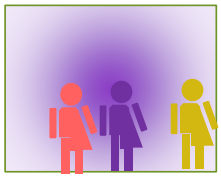
In large volume scarcely occupied, the CO_2 level will remain low, so the ventilation will remain low while there may still be a need for ventilation

No recommendations from ASHRAE

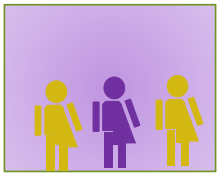
What do we need to agree on that?

How does the infected aerosols naturally mix in the air?

- Could a CO_2 sensor associated to a mixing fan be more relevant?
- In case of social distancing is mixing still relevant?



or

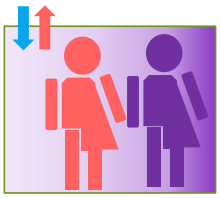


Is it OK to have a small air-renewal in a large volume scarcely occupied in the context of Covid 19?

- If the building is flushed after occupation?

Is the answer the same if there is air-cleaning/recirculation?

Do we need the same flowrate in those 2 configurations?



Possible reasons behind those differences

- Typical ventilation systems in Europe and US are different.
  - Europe relies on outdoor air ventilation and air conditioning that is typically separated from hydronic heating
  - In the US, all-air-systems for air conditioning including heating and cooling and air recirculation with minimal fresh air are commonly used.
- ASHRAE recommendations are more influenced by energy use
- The impact of thermal conditions is considered to be more important for ASHRAE than for REHVA It may be partly due to a better acceptation of adaptative comfort in Europe than in the US.
- Regarding filters, REHVA, recommending HEPA and ePM1 80% filters, has a more "safe-side" approach than ASHRAE who recommends MERV 13 filters but with higher flowrate.
- Recirculation with high efficiency filtration has been the basic approach to healthcare ventilation in ASHRAE Standard 170 for a long time

What do we need now?

Research

- On the virus itself but also on the efficiency of air cleaners

New standards for ventilation systems that make systems "epidemy-ready"

- High capacity/ Demand control ventilation systems in future buildings
  - Full speed in epidemic conditions,
  - According to demand control in normal condition

For each typology of building/occupation

- Define the main objective
  - Limit the risk of virus propagation / limit side-effects (energy use, thermal stress)
- Adapt the recommendation to the objective and the specificities of the building.