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 and other technical measures to remove infected aerosols are necessary to reduce 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 and carry out 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 for the working group. This way we hope to expand the FAQ-section, also posted on the AIVC-website. Many other international organizations in the domain of HVAC, health care and disease prevention have developed information and guidance documents to support decision makers and the 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, with detailed information 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

Editorial

AIVC Newsletter Special Issue
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

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
the virus. In these circumstances, higher
increase the emission of aerosols containing
outdoor concentrations. Occupant activities,
based on the space and its use, and the
CO₂ concentrations should be determined
consequently occupants are likely to be at a
can provide a crude indication that a
In some circumstances a CO₂ concentration
may be considered to be under ventilated.
There are circumstances where a CO₂
concentration cannot be used as a proxy for
under ventilation. For example, in low
occupancy or large volume spaces where
there is much less certainty in the
relationship between CO₂ concentration and
the ventilation rate.
Finally, CO₂ should not be used when its
source is not exclusively from people, such as
combustion devices.

Can a measured CO₂ concentration show a building is SARS-CoV-2 safe?
Benjamin Jones, University of Nottingham,
Jelle Laverge, Ghent University & Pawel
Wargocki, Technical University of Denmark
An indoor CO₂ concentration is commonly
used as an indicator of the ventilation rate
in indoor spaces, albeit with great
uncertainty. Its concentration depends on
the number, demographics, and activities of
occupants, the outdoor air supply rate,
mixing, inter-zonal airflow, the air renewal
rate, and the outdoor concentration.
When using CO₂ as an indicator, a steady-
state concentration must be achieved.
Consequently, measurements should
typically be made over at least 1 hour to
ensure a representative reading. The
placement, mixing of air within a space, and
accuracy of sensors must be accounted for
when analyzing measured data.
The rate at which people shed the virus
depends, among other factors, on
respiratory activity, such as speaking,
singing, coughing, and sneezing, physical
activity, and demographics. The dose is a
function of occupant physical activity,
airborne aerosols concentration, and
exposure time.
A CO₂ concentration does not indicate with
much certainty that the occupants of a
building are safe from airborne exposure to
the SARS-CoV-2 virus and is not
recommended as a reliable proxy of the risk
of airborne exposure to the virus. This is
particularly true in spaces where there is
filtration and UV-C radiation because they
eliminate the virus but not the CO₂.
In some circumstances a CO₂ concentration
can provide a crude indication that a
building is not adequately ventilated and
consequently occupants are likely to be at a
higher risk of exposure to the virus. Limiting
CO₂ concentrations should be determined
based on the space and its use, and the
outdoor concentration. Occupant activities,
such as singing, loud speech, and exercise,
increase the emission of aerosols containing
the virus. In these circumstances, higher
than normal ventilation rates are advised.
However, as a rule-of-thumb, if the CO₂
concentration is >1400 ppm the building
must have a clean air delivery rate (CADR)
that is sufficient for the characteristics of
the desired room.
GGUV, also known as UVGIs uses ultraviolet
light in the UV-C wavelength range (200 nm
to 280 nm) to inactivate microorganisms.
Most systems use low-pressure mercury
lamps that produce a peak emission of
approximately 254 nm. The virus that
causes COVID-19 is susceptible to GUV, so if
it is irradiated for a sufficiently long period
of time, it becomes inactivated. There are
three air disinfection applications on the
market. One application is upper-room
germicidal systems, the other is UVI Gi
cleaners used in HVAC systems, and the
third is portable air cleaners. The upper-
room systems can reduce the amount of
active virus in the air by an equivalent of 10
air changes per hour or more of outdoor air
at a much lower energy cost (3). The other
application is UVI Gi cleaners in HVAC
systems that are designed to destroy/inactivate viruses in the flowing air stream
as they pass through the device. Portable air
cleaners can incorporate UV-C lamps in their
design in order to destroy and remove
viruses trapped on air filter medium
surfaces. According to SAGE_EMG, there is
good evidence that GUV, using UV-C light, is
likely to be a viable decontamination
approach against SARS-CoV-2 for
unoccupied rooms (4). There are several
portable devices on the market that show
good single-pass efficiency.
However, their effectiveness in a room is
dependent on their flow rate relative to the
room size; many devices have an insufficient
airflow rate to be very effective in practice.
Finally, it is important to mention that air
cleaners cannot fully replace a ventilation
system. Please visit the IEA EBC Annex 78
“Supplementing Ventilation with Gas-phase
Air Cleaning, Implementation and Energy
Implications website to know more.

References
Environ. Res. Public Health 2020, 17, 6960
113(4):413-8.
4. SAGE – Environmental and Modelling Group. Application of UV disinfection, visible light, local air filtration and fumigation
technologies to microbial control. 31 July, 2020.
Are Covid-19 recommendations of REHVA & ASHRAE similar?

Valérie Leprince, INIVE

REHVA and ASHRAE agree on their main recommendations, but there are some slight differences in the specifics.

Both REHVA and ASHRAE note that long-range aerosol-based transmission is possible and that ventilation plays an important role to limit the risk of transmission. They stress the need to increase ventilation flowrate (more air renewal) for more dilution and reduction of pollutants concentration. However, the specific ventilation rate to most effectively reduce the risk of transmission of airborne particulate matter is unknown.

Therefore, the questions below remain open and REHVA and ASHRAE have slightly different answers.

Various explanations can be found for those differences including:

• Typical ventilation systems in Europe and US are different. While Europe relies on outdoor air ventilation and air conditioning that is typically separated from hydronic heating, in the US all systems for air conditioning typically include heating and cooling and air recirculation with minimal minimal outdoor air intake.

• The impact of thermal conditions is considered to be more important for ASHRAE than for REHVA. It may be partly due to a better acceptance of adaptive 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.

According to REHVA & ASHRAE, how much should ventilation level be increased?

REHVA proposes to adopt the principle of ALARA (As Low as Reasonably Achievable) for the concentration of pollutants. REHVA and ASHRAE agree that mechanical ventilation rate should be set at its reasonable maximum, that DCV system should be overruled (by a setpoint at 400ppm for CO₂) and that rooms should be “flushed” before and after occupancy. REHVA recommends 800 ppm CO₂ (absolute value) as a proxy of good ventilation.

However, while ASHRAE warns against causing thermal stress, and thereby lowering resistance to infection, and estimate that other methods should be considered first when the energy/comfort/ IAQ conditions warrant, 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).

According to REHVA & ASHRAE how should recirculation be used?

ASHRAE recommends upgrading recirculation filters to MERV 13 and does not recommend switching off recirculation. When using MERV 13 filters, ASHRAE recommends maximizing flow through the filter to remove as many infected aerosols as possible. In general, ASHRAE notes that dilution, filtration and disinfection all act together and that in many circumstances filtration can be more effective than increased ventilation.

REHVA recommends to close recirculation dampers even if they have air filters. If recirculation cannot be avoided, additional measures for return air filtering should be taken with the installation of HEPA filters or at least ePM1 80% filter (MERV 13 are to be compared to ePM1 50% filters).

For room level recirculation, ASHRAE does not have specific recommendations, while REHVA recommends either to switch off the system or run the fan constantly at low speed (to avoid the collection and release of contaminated particles). However, currently REHVA is updating fan coil recommendations in their version 4 guidance with the focus on sufficient outdoor air ventilation and warning for possible high velocity directed airflows.

According to REHVA & ASHRAE, are filters effective to filter or inactivate virus?

While ASHRAE suggests that MERV 13 filters are sufficient to catch infected aerosols, and estimates that high air change rates through moderately high-efficiency filters do help, REHVA implies that only HEPA filters can filter all virus particles effectively, however accepting ePM1 80% filter as a minimum improvement.

Ultraviolet Germicidal Irradiation (UVGI) technologies are recommended by ASHRAE in all kinds of buildings, while REHVA only states that “UVGI” and Germicidal Ultraviolet “GUV” may be used.

According to REHVA & ASHRAE, how should portable air-cleaning devices be used?

Both ASHRAE and REHVA recommend using portable air-cleaning systems, but 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 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.

According to REHVA & ASHRAE, can heat-recovery sections be used?

ASHRAE provides extensive information to evaluate on-site the risk of unwanted recirculated air in heat recovery sections, and according to the fan arrangement may recommend to by-pass the heat recovery.

REHVA does not provide a method to ensure that there is a 100% air separation but recommends to by-pass heat recovery or to adjust the pressure if critical leaks are detected for rotary air to air heat exchanger.

References
Selection of FAQs related to COVID-19 - As developed by IEQ-GA, ASHRAE, REHVA, WHO & SAGE-EMG

**The Indoor Environmental Quality – Global Alliance (IEQ-GA)** and in particular its members involved in the IEQ-GA Task Force on COVID-19, developed a series of *Questions & Answers (Q&A)* intended to address concerns about COVID-19. The AIVC is member of the IEQ-GA.

1. Can opening windows, as WHO suggests in some cases, give the same result of a mechanical ventilation system with respect to COVID-19 pandemic?
2. How can I best manage my HVAC system to reduce the risk of the spread of COVID-19?
3. How can I best manage an all-air systems (heating and air-conditioning) serving a large office building to reduce the risk of the spread of COVID-19?
4. How can I best manage all-air systems (heating and air-conditioning) serving a few spaces under the same ownership to reduce the risk of the spread of COVID-19?
5. How can I best manage primary air systems to reduce the risk of the spread of COVID-19?

**The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)** has an *Frequently Asked Questions (FAQ)* section on its website. An example of interesting questions is given below.

1. My home has wall-mounted ductless mini-split AC units. I know their filtration is minimal. Can I improve filtration of small and potentially infectious airborne particles?
2. Is it safe to continue use my ERV or HRV to provide ventilation in my single-family home?
3. What is the size of the SARS-COV-2 virus, and can it be captured by ventilation filters?
4. Is it OK to have a blower door test done on my house and if so, should I take special precautions?
5. What is the proper amount of outside air to spaces where infections exist or are known to have occurred?

**The Federation of European Heating, Ventilation and Air Conditioning associations (REHVA)**, has received several questions and requests for clarifications from industry, academia and government experts, related to the REHVA Guidance document. *REHVA's COVID-19 FAQs webpage* provides answers.

1. What are the recommended rates of air exchange for different types of workplaces such as offices, shops, factories and so on.
2. How does this relate to level of occupancy? Presumably you need faster turnover in crowded places?
3. Is there a recommended maximum CO₂ level?
4. Is it safe to recirculate warm air after filtering?
5. Can filters actually remove viral particles?


1. What is WHO doing to address ventilation in the context of COVID-19?
2. Can I use air conditioning in the context of COVID-19?
3. Can fans be used safely in indoor spaces?
4. What steps can be undertaken to improve the ventilation in indoor public spaces and buildings?
5. How can ventilation reduce the risk of contracting COVID-19 in airplanes?

**The Scientific Advisory Group for Emergencies (SAGE)** provides scientific and technical advice to support the UK government decision makers during emergencies. The Environmental and Modelling Group (EMG) has produced a document entitled “*Role of Ventilation in Controlling SARS-CoV-2 Transmission*”.

1. How is the risk of airborne transmission impacted by the level of ventilation?
2. To what degree does the density of people within a setting influence airborne transmission risk and consequently ventilation requirements?
3. To what degree does the density of people within a setting influence airborne transmission risk and consequently ventilation requirements?
4. How can CO₂ sensors be used to understand ventilation effectiveness?
5. What steps could be taken to improve ventilation and what would be needed to achieve this?
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