AIVC Newsletter Special Issue COVID-19

Editorial

We hope you are keeping safe and healthy during this challenging period. As announced in the November issue of the AIVC newsletter, the AIVC board decided 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.

One of the outcomes of the project is the development of a number of questions and answers by working group members to address issues in relation to COVID-19 and building ventilation in line with most recent scientific understanding. This 2nd special issue of the AIVC newsletter presents a new set of question and answers provided by the working group. More elaborate answers are available on the FAQ-section of the AIVC-website, which received an upgrade, together with the Q&A's addressed in the previous newsletter.

The AIVC working group also organizes a number of webinars in line with the project objectives. The webinar "**COVID-19 Ventilation related guidance by ASHRAE and REHVA**" was held on November 20th, 2020 with support from ASHRAE (https://www.ashrae.org/) and REHVA (https://www.rehva.eu/). 406 people from 42 countries attended the webinar. Due to the high numbers of attendance, there were several questions addressed to the speakers who did not manage to answer to all within the event's timeframe. The article available **here** includes edited transcripts of the answers given by the speakers during the event and provides answers to the non-answered questions.

A new **webinar**, digging deeper into the role of building ventilation on COVID-19 transmission is planned on April 1st, 2021. You may find more information in this newsletter.

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

Arnold Janssens, AIVC COVID-19 Working Group chair

1 April 2021 (17:00-18:30 CET) – AIVC Webinar – Building ventilation: How does it affect SARS-CoV-2 transmission?

In this webinar, we address the potential mitigating role of building ventilation in the spread of the COVID-19 pandemic. In the first part of the webinar, we look at building ventilation as one of the mechanisms that affects exposure to infectious aerosol and the uncertainty in relating exposure to airborne transmission of the virus. In the second part of the webinar, we focus on the airflow in real indoor environments, with results from field experiments with aerosol sources and the use of pressure difference in buildings to control the spread of aerosols. This webinar is organized by the Air Infiltration and Ventilation Centre (www.aivc.org/) & the IEA EBC Annex 86 "Energy Efficient Indoor Air Quality Management in Residential Buildings" (https://annex86.iea-ebc.org/). The webinar is facilitated by INIVE (http://www.inive.org/).

Programme

- 17:00 | Introduction, *Arnold Janssens – chair of AIVC WG COVID-19, Ghent University, Belgium*
- 17:10 | The Role of Building Ventilation in Indoor Infectious Aerosol Exposure, *Andrew Persily – NIST, USA*
- 17:25 | Modelling uncertainty in the relative risk of exposure to the SARS-CoV-2 virus by airborne aerosol transmission, *Cath Noakes – University of Leeds, UK*
- 17:40 | Questions and Answers
- 17:50 | Field measurements of aerosol exposure in indoor environments, *Wouter Borsboom – TNO, Netherlands*
- 18:05 | Ventilation system design and the risk areas for spreading airborne contaminants in office buildings, *Alireza Afshari – Aalborg University, Denmark*

18:20 | Questions and Answers

18:30 | Closing & End of Webinar

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

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February 2021

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

COVID-19 Working Group FAQs

Does transport of air from one room to another room play a role in relation to COVID-19?

Willem de Gids, VentGuide, Arnold Janssens, Ghent University, Alireza Afshari, Aalborg University, Gaëlle Guyot, Cerema, Univ. Savoie Mont Blanc

Yes it does. On the one hand, it may spread or disperse viruses from rooms with infection sources to other parts of the building, and on the other hand it may dilute the concentration of infected aerosols in a room where infection sources are present when uncontaminated air is transported from adjacent rooms into the room with infection sources. Transport of air in between rooms may occur through dedicated ventilation transfer openings, through leakage paths in partition walls between rooms, or through open doors. Whether or not transport of air from one room to another is an important phenomenon in the transmission of COVID-19, is depending on many factors, such as the position and strength of infection sources in the rooms, the air flow rates from outside and in between rooms, and the occupancy of different rooms in a building.

Ideally one wants to have a contaminated room in negative pressure relative to other parts of the building. Hence the contamination is kept in the contaminated room and can be diluted to an acceptable level by ventilation. For example, ventilation systems for rooms in hospitals for patients with infectious diseases are designed according to these principles. Still, at the time of writing there is insufficient scientific knowledge to define what ventilation rates are needed to prevent infection from the virus that causes COVID-19. Pressure control is achieved by controlling the flow balance between the supplied and exhausted ventilation airflows to and from a room, often using a mechanical ventilation system. The pressure difference depends on the airtightness of the building envelope and the interior walls, and on the ventilation flow balance.

How long should a room be ventilated after occupation to reduce the concentration of infectious aerosols?

Willem de Gids, VentGuide & Arnold Janssens, Ghent University

Assuming an infected person has occupied the room, the room should be ventilated until the concentration of infectious aerosols is decreased to an acceptable level before it is used again by other persons. At the time of writing there is however insufficient scientific knowledge to define what is an acceptable level.

Still, it is possible to estimate how long a room should be ventilated to reduce the aerosol concentration down to a level relative to the initial concentration. Ventilation in most cases is mixing the air and diluting the contaminant. As a result the concentration decreases exponentially when no further contaminant production is present and ventilation occurs with uncontaminated air. Assuming complete mixing of air, and negligible influence of settling and inactivation of infectious aerosols, the decay from the initial concentration depends on the product of the air change rate of a room and the ventilation time. The air change rate expresses the rate at which a room volume is replaced by uncontaminated, typically outside air. Replacing the room volume with the same volume of outside air in a given time, does not mean the room is completely clean after that time. Table 1 shows the ratio between the concentration at a given moment and the initial concentration as a function of time and air change rate.

Table 1: Relative concentration as a function of ventilation time and air change rate

Air change rate: (per hour)	0.5	1.0	2.0	4.0
After 15 minutes	88%	78%	61%	37%
After 30 minutes	78%	61%	37%	14%
After 60 minutes	61%	37%	14%	2%
After 120 minutes	37%	14%	2%	0%

A faster reduction of contaminant concentrations requires increasing the air change rate, as is expressed in the following Equation:

$$t = \frac{1}{n} ln \frac{C(t)}{C_0}$$

where t is the ventilation time (h), n is the air change rate (h^{-1}), C(t) is the concentration at time t, and C_0 is the initial concentration.

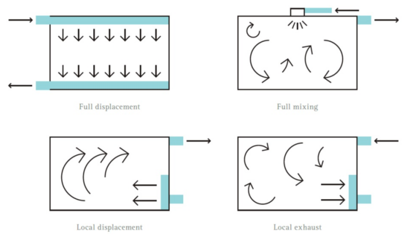
So, in order to reduce the contaminant concentration to 1% of its initial concentration a room should be ventilated for more than 9 hours at an air change rate of 0.5 air changes per hour, or for about 1 hour and 10 minutes at an air change rate of 4 air changes per hour.

Is ventilation the same as air movement in relation to COVID-19?

Willem de Gids, VentGuide

No. Ventilation is air exchange between inside and outside. It dilutes the concentration of contaminants, and hence helps to control aerosol-based cross-infection risk of COVID-19.

There are several ways to ventilate a room:

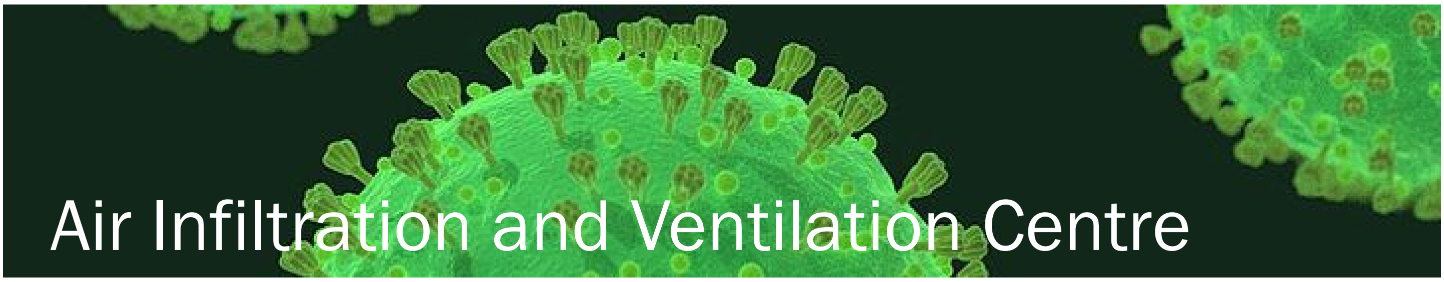


Examples of the four basic principles of ventilation: full displacement, full mixing local displacement and local exhaust (AIVC TN 68: Residential Ventilation and Health, 2016)

Full displacement ventilation is normally only applied for specific applications such as clean rooms and operating theaters.

In most buildings, ventilation systems try to achieve complete or full mixing.

Air movement always exists in a room. It can be driven by thermal and mechanical forces. Ventilation causes air movement and hence transport of air within one room, but can also cause air transport from one room to another. Air movement in a room contributes to the spread of aerosols and to the long-range airborne transmission of COVID-19. With effective mixing ventilation, the aerosol concentration is almost constant from 1-1.5 m distance from an infection source. In practice, there may however be differences in exposure over longer distances, depending on the ventilation supply air velocity, or on local air flow patterns in a room.



Note: The answers below are short versions of the original answers provided by the AIVC WG. The full length answers can be found at: https://www.aivc.org/resources/faqs

Can building's ventilation substitute mask wearing and social distancing while preventing COVID-19 transmission?

Gaëlle Guyot, Cerema, Univ. Savoie Mont Blanc, Jelle Laverge, UGent & Willem de Gids, VentGuide

No. Ventilation cannot replace masks and social distancing because these actions deal with the reduction of the spread of aerosols containing COVID-19. One cannot rely solely on a ventilation strategy of dilution to reduce the risk of COVID-19 to a low level sufficient to prevent COVID-19 infection. However, ventilation solutions are important in addition to physical distancing to control cross-infection risk in indoor spaces.

How much ventilation is needed to limit COVID-19 aerosol-based transmission?

Gaëlle Guyot, Cerema, Univ. Savoie Mont Blanc, Jelle Laverge, UGent & Willem de Gids, VentGuide

We don't know. The quantity of ventilation needed depends on the amount and nature of the SARS-CoV-2 aerosols. If the emission characteristics of SARS-CoV-2 and the dose-response curve would be known, then it would be possible to calculate the rate of ventilation needed to prevent occupants' exposures exceeding a predefined safe dose. At the moment of writing there is however insufficient scientific knowledge to define this rate. Based on what we know about the variables involved, the required airflow rates can vary substantially depending on the situation.

Can air infiltration provide sufficient air supply with respect to COVID-19?

Peter Wouters, INIVE

It is not correct to assume that a poor airtightness level can guarantee during most circumstances a sufficient ventilation rate for normal occupancy. In case of most modern buildings with typically a rather good to very good airtightness level i.e., n_{50} of the order of 3 h^{-1} or better, there will be insufficient air infiltration during most of the time for covering the ventilation needs under normal occupation and certainly in the COVID-19 context.

REHVA calculator to estimate the effect of ventilation on COVID-19 airborne transmission

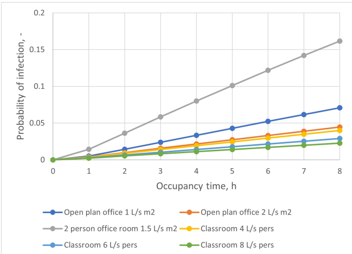
Jarek Kurnitski, REHVA

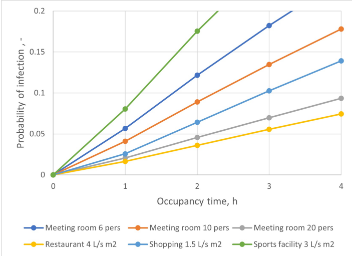
In November 2020, REHVA published the REHVA Calculator, together with the updated REHVA COVID-19 guidance. The REHVA Calculator is a tool for experts to estimate the effect of ventilation on COVID-19 airborne transmission. The tool was developed by Prof. Jarek Kurnitski and the REHVA COVID-19 Task Force for specialists with at least a minimum understanding of ventilation and air distribution. The tool is available for download for experts who have read and understood the related COVID-19 guidance document, as well as the explanation on the use of the tool or are enrolled in the REHVA COVID-19 course.

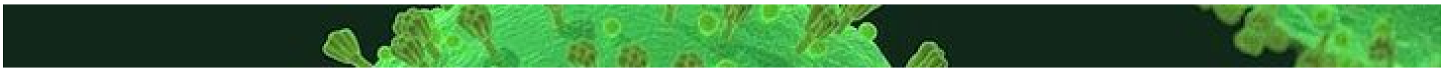
The tool is based on a standard airborne disease transmission Wells-Riley model, which applies also for COVID-19 if correct source strength is used. With this calculator it is easy to calculate infection risk probabilities for any specific room – just by the input of geometry and ventilation rate, for most of common indoor activities. Other parameters needed for the infection risk calculation, and likely not so well known by engineers, have a selection of default values in the tool to describe speaking or just breathing or physical activities in gyms. While the ventilation is the main virus removal mechanism, other removal mechanisms as deposition and deactivation are described based on latest information available in scientific literature. This makes it possible to limit the user input to outdoor ventilation rate and the room area and volume. The calculation is based on full mixing assumption but the time dependent virus concentration is calculated. Recirculation cannot be calculated with this single zone model. Air cleaner is possible to add so that a clean air delivery rate in 1/h units are needed for the input. The tool enables to conduct a risk assessment that is recommended to decide how to operate buildings and if necessary to limit occupancy time or in some spaces the number of occupants.

Examples calculated with the tool as shown in Figure 1 illustrate how virus laden aerosols may be removed by ventilation. The results show that with Category II ventilation rates according to existing standards, the probability of infection is reasonably low (below 5 %) for open-plan offices, classrooms, well-ventilated restaurants, and for short, no more than 1.5-hour shopping trips or meetings in a large meeting room. Small office rooms occupied by 2-3 persons and small meeting rooms show a greater probability of infection, because even in well ventilated small rooms the airflow per infected person is much smaller than that in large rooms. Therefore, in an epidemic situation small rooms could be safely occupied by one person only. In normally ventilated rooms occupied by one person there is no infection risk at all because of no emission source. There is also a very visible difference between 1 L/s m² and 2 L/s m² ventilation rate in an open plan office (note that 1 L/s m² is below the standard). Speaking and singing activities are associated with high quanta generation, but also physical exercises increase quanta generation and breathing rate that directly affects the dose. Thus, many of indoor sports facilities (excluding swimming pools and large halls) are spaces with higher probability of infection if not specially designed for high outdoor ventilation rates.

Figure 1: Infection risk assessment for some common non-residential rooms and ventilation rates. 1.5 L/s per m² ventilation rate is used in 2 person office room of 16 m², and 4 L/s per m² in meeting rooms.







Air Infiltration and Ventilation Centre

Previously published FAQ related to COVID-19

The AIVC special COVID-19 newsletter of November 2020, included a first set of FAQs developed by the Working Group. Click on the questions below to know more:

- ***Can portable air cleaners prevent the spread of COVID-19 indoors?***
- ***Can a measured CO2 concentration show a building is SARS-CoV-2 safe?***
- ***Are COVID-19 recommendations of REHVA and ASHRAE similar?***

AIVC's COVID-19 Working Group (WG) members

Alireza Afshari, Aalborg University, Denmark

Andrew K. Persily, NIST, USA

Arnold Janssens, Chair of AIVC Working Group on COVID-19, Ghent University, Belgium

Benjamin Jones, University of Nottingham, UK

Gaëlle Guyot, CEREMA, France

Jaap Hogeling, REHVA

James Mc Grath, National University of Ireland Galway

Jelle Laverge, Ghent University, Belgium

Max H. Sherman, Lawrence Berkeley National Laboratory, USA

Pawel Wargocki, Technical University of Denmark, Denmark

Peter Wouters, Operating Agent AIVC

Sonia Garcia Ortega, Eduardo Torroja Institute for Construction Science, Spain

Valérie Leprince, PLEIAQ, France

Willem de Gids, VentGuide, Netherlands

Wouter A. Borsboom, TNO, Netherlands

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Conclusions and opinions expressed in contributions to AIVC's Newsletter represent the author(s)' own views and not necessarily those of the AIVC

AIVC Countries & board members

Australia: Mat Santamouris, University of New South Wales

Belgium: Arnold Janssens, University of Ghent • Samuel Caillou, BBRI

China: Guoqiang Zhang, Hunan University • Zhengtao Ai, Hunan University

Denmark: Bjarne Olesen, Technical University of Denmark • Alireza Afshari, Danish Building Research Institute, Aalborg University

France: François Durier, CETIAT • Nicolas Doré, ADEME

Greece: Dimitris A. Charalambopoulos, ASHRAE Hellenic Chapter • Alkis Triantafyllopoulos, ASHRAE Hellenic Chapter

Italy: Lorenzo Pagliano, Politecnico di Milano

Ireland: Simon Jones, Aereco • Marie Coggins, NUI Galway

Japan: Takao Sawachi, Building Research Institute • Yoshihiko Akamine, NILIM

Netherlands: Wouter Borsboom, TNO

New Zealand: Manfred Plagmann, BRANZ

Norway: Kari Thunshelle, SINTEF Byggforsk

Republic of Korea: Yun Gyu Lee, Korea Institute of Construction Technology • Jae-Weon Jeong, Hanyang University

Spain: Pilar Linares Alemparte, The Eduardo Torroja Institute for Construction Science - CSIC • Sonia García Ortega, The Eduardo Torroja Institute for Construction Science - CSIC

Sweden: Pär Johansson, Chalmers University of Technology

UK: Benjamin Jones, University of Nottingham • Maria Kolokotroni, Brunel University London

USA: Andrew Persily, NIST • Max Sherman, LBNL

Operating agent

INIVE EEIG, www.inive.org, info@aivc.org

Peter Wouters, operating agent • Maria Kapsalaki, senior consultant • Stéphane Degauquier

Representatives of organisations

- Takao Sawachi, IEA EBC
- Carsten Rode, IEA EBC Annex 68
- Pawel Wargocki, IEA EBC Annex 78
- Peter Holzer, IEA EBC Annex 80
- Jelle Laverge, IEA EBC Annex 86
- Jan Hensen, IBPSA
- Donald Weekes, IEQ-GA
- Ben Hughes, International Journal of Ventilation
- Jaap Hogeling, REHVA

AIVC board guests

Francis Allard • Willem de Gids • Laszlo Fulop • Zoltan Magyar • Hiroshi Yoshino