REHVA COVID guidance ver_4

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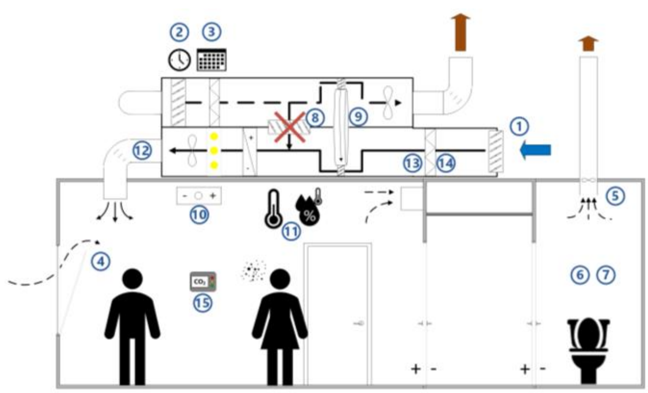
15 recommendations for existing buildings

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



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

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:

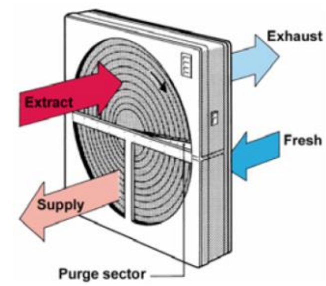
1. **Allow to switch ventilation off during night time and weekends (no evidence against that)**
2. **Toilets exhaust can be operated in the same fashion as main AHUs**

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

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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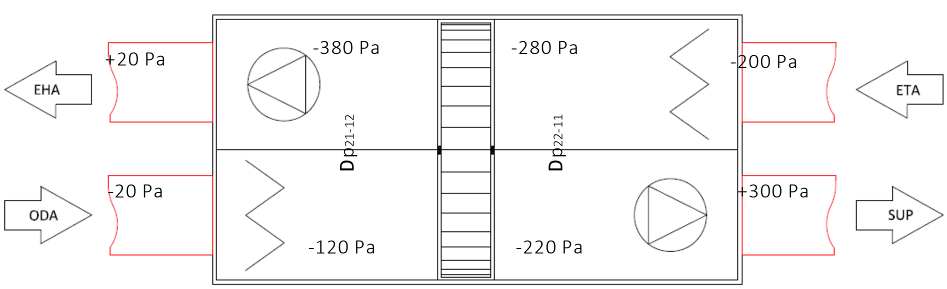
Inspection of rotary heat exchangers to limit internal leakages



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**

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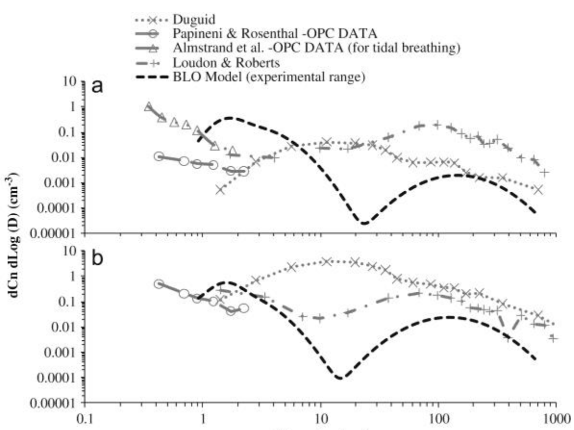
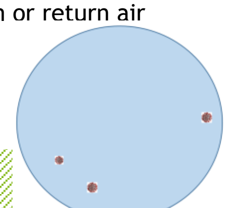
Filtration with ePM1 80% (former F8) filters



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



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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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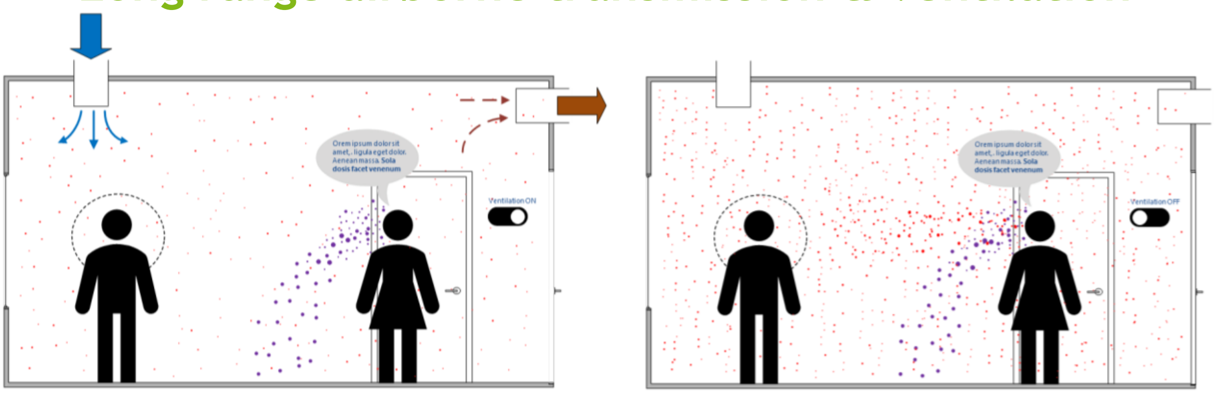
Long range airborne transmission & ventilation



- 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)

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)

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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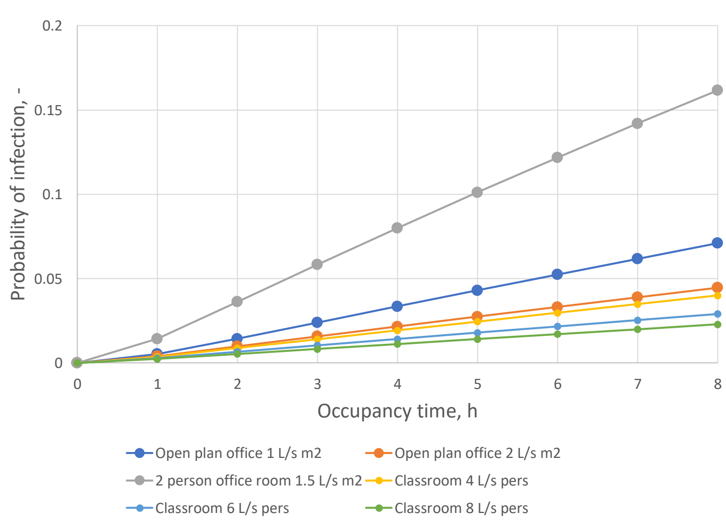
(New appendix in the ver_4 guidance)

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)

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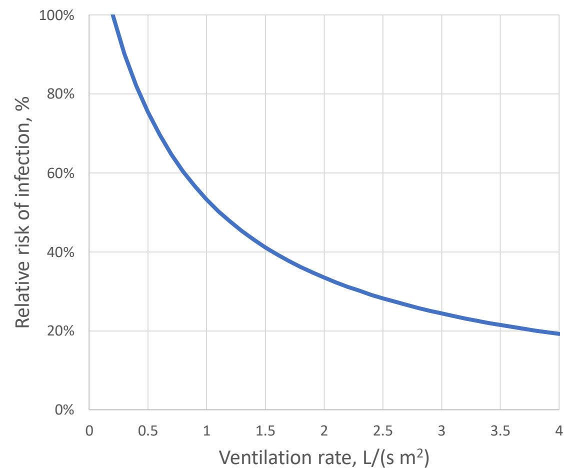
Converting results to relative risk

- 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)

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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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