Revision of European standard EN 16798-1: Ventilation and air cleaning in reducing airborne transmission

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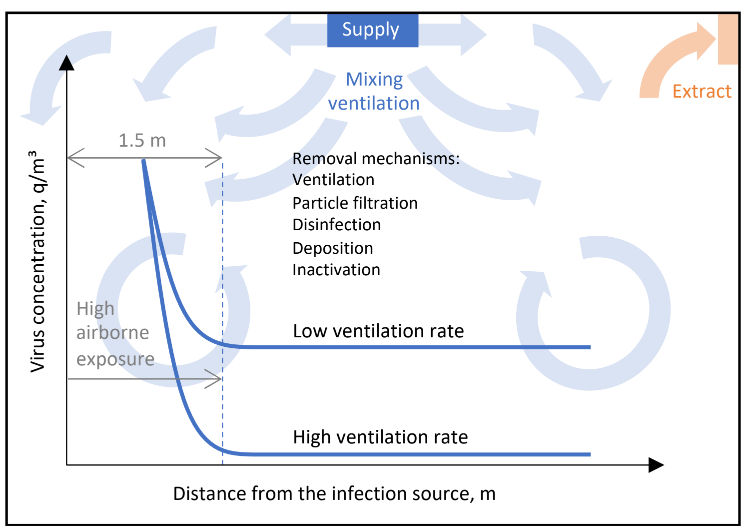
1

2

HVAC design for airborne transmission

- Exposure = dose is a product of the breathing rate, **concentration** and time
- Concentration control of virus containing particles: remove with **outdoor air ventilation** and **filtration** or deactivate with **UVG**
- **General ventilation** solutions for >1.5 m may be complemented with **personal ventilation** and room partitioning/zoning



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2

EN 16798-1 revision: Design for Health and Airborne Transmission

- Provides an opportunity for infection risk based ventilation design – not mandatory
- Calculation method of Wells-Riley model modification with latest dose-response model and quanta emission rates https://doi.org/10.1016/j.buildenv.2022.109924
- While quanta values have high variations, median viral load values provided as defaults in the informative annex, however may be specified in national annexes
- Infection risk control concept based on basic reproduction number $R_0 = 1$ during pre-symptomatic infectious period accounting all possible out-of-home interactions with susceptible persons https://doi.org/10.1016/j.enbuild.2023.113386
- For non-residential buildings (residential and health care settings excluded)
- Provides space category specific target ventilation rates for fully mixing air distribution
- Introduces point source ventilation effectiveness for actual air distribution solution

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Complementary for perceived air quality ventilation

Current ventilation criteria is based on perceived air quality by the visitors (unadapted) and occupants (adapted persons) that depend on the emissions from humans and building materials

Outdoor air flow rate:

$$q_{tot} = nq_p + A_R q_B$$

where
q_{tot} = total ventilation rate for the breathing zone, L/s
n = design value for the number of the persons in the room,
q_p = ventilation rate for occupancy per person, L/(s* person)
A_R = room floor area, m^2
q_B = ventilation rate for emissions from building, L/(s,m^2)

For low polluting materials (1 L/s = 3.6 m^3/h):

10 L/s per person + 1 L/s per floor area in Category I;

7 L/s per person + 0.7 L/s per floor area in Category II;

4 L/s per person + 0.4 L/s per floor area in Category III.

Cat II will lead to 2-2.5 ach in offices and 5 ach in classrooms and meeting rooms

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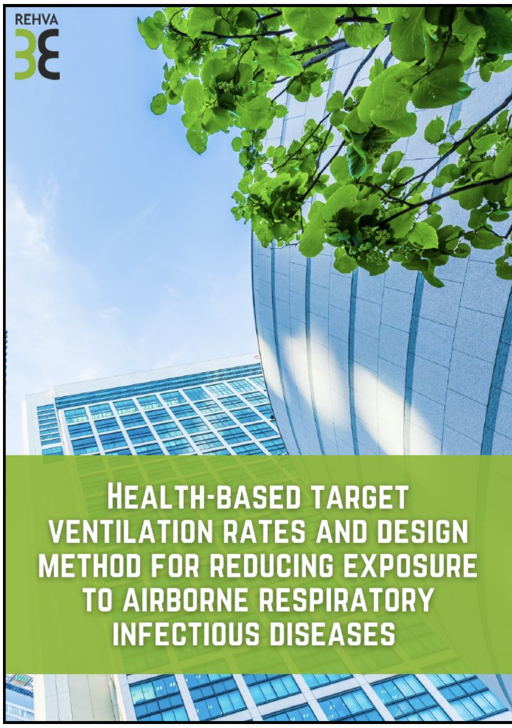

Follows proposal by Nordic Ventilation Group and REHVA

Target outdoor air ventilation rates *Q* (L/s) are calculated using the number of persons in room *N* (-) and the room volume *V* (m³)

Space category	Ventilation rate, L/s
Classroom	Q = 10(N-1) – 0.24V
Office	Q = 23(N-1) – 0.24V
Assembly hall	Q = 30(N-1) – 0.24V
Meeting room	Q = 40(N-1) – 0.24V
Restaurant	Q = 40(N-1) – 0.24V
Gym	Q = 70(N-1) – 0.24V

Design ventilation rate supplied by the ventilation system:

$$Q_s = \frac{Q}{\varepsilon_b}$$

ε_b point source ventilation effectiveness for the breathing zone (-)

https://www.rehva.eu/activities/post-covid-ventilation

5

Proposed implementation in EN 16798-1 revision

6

- Infection-risk based target ventilation rates for fully mixing air distribution – generic equation (originally based on quanta, but may be also on relative risk reduction):

$$Q = q_q(N-1) - q_r V$$

where

Q target ventilation rate (L/s) (sum of outdoor and clean recirculated airflow rate)
q_q quanta emission specific ventilation rate for occupancy per person (L/(s person))
q_r removal rate of virus decay and deposition (L/(s m³))
N **the number of persons in the room**
V **room volume (m³)**

- q_q (viral load and risk level) and q_r (removal mechanisms) are virus specific parameters
- This equation may also be used to calculate allowed N at given ventilation rate

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Kurnitski et al. 2023 https://doi.org/10.1016/j.enbuild.2023.113386

Proposed implementation in EN 16798-1 revision

7

- Tabulated values for virus specific ventilation parameters q_q and q_r

Space category	q_q, L/(s person)	q_r, L/(s m³)
Classroom	10	$0.24 + k_f/3.6$
Office	23	$0.24 + k_f/3.6$
Assembly hall	30	$0.24 + k_f/3.6$
Meeting room	40	$0.24 + k_f/3.6$
Restaurant	40	$0.24 + k_f/3.6$
Gym	70	$0.24 + k_f/3.6$

- In the case of no air cleaner, filtration removal rate (1/h) $k_f = 0$

$$k_f = \frac{Q_f \eta_f}{V}$$

- There are no IEQ categories in this case
- Tabulated values are informative (Annex B) and may be provided in the national annex

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Proposed implementation in EN 16798-1 revision

8

- Design ventilation rate supplied by the ventilation system Q_s is calculated with point source ventilation effectiveness ε_b for the breathing zone:

$$Q_s = \frac{Q}{\varepsilon_b}$$

- ε_b is to be calculated as an average of two or more tracer gas measurements with different source locations (or CFD simulations):

$$\varepsilon_b^j = \frac{C_{je} - C_{jo}}{C_{jb} - C_{jo}}$$

$$\varepsilon_b = \frac{\sum_j \varepsilon_b^j}{m}$$

- or with more dedicated method

where

ε_b^j	point source ventilation effectiveness of measurement *j*
ε_b	point source ventilation effectiveness for the breathing zone
C_{je}	measurement *j* concentration in the extract air duct
C_{jb}	measurement *j* concentration at the breathing level
C_{j0}	concentration in the supply air
m	total number of measurements with different point source locations

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Ventilation effectiveness

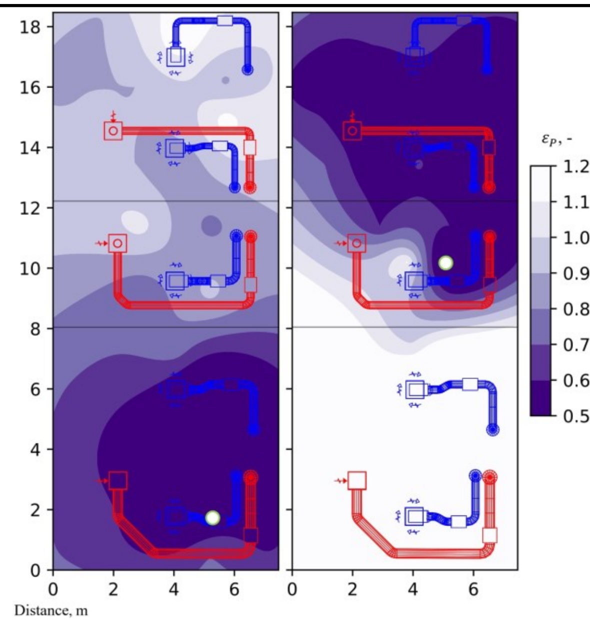
- To be determined with the point source (=infector)
- Existing values do not apply because measured with distributed source (=normal occupancy)

$$Q_s = \frac{Q}{\varepsilon_b}$$

$$\varepsilon_{P,i} = \frac{C_e - C_o}{C_i - C_o}$$

- ε_b can be calculated from local air quality index values:

$$\varepsilon_b^j = \frac{1}{\frac{\sum_{i=1}^{k}\left(\frac{1}{\varepsilon_{P,i}}\right)}{k}}$$



Large teaching space of 130 m² with 4 L/(s m²) ventilation: ε_b^1=0.76 (left) and ε_b^2=0.77 (right) and the average value of two measurements ε_b=0.76

Calculation examples for typical rooms

	Floor area m²	Room height m	No of persons N, -	Infection-risk-based ventilation: Ventilation effectiveness ε_b, -	Ventilation rate L/(s pers)	Ventilation rate L/(s m²)	Air change rate 1/h	CO_2 conc. ppm	Comfort ventilation: Cat. II ventilation L/(s m²)	Cat. I ventilation L/(s m²)
Small classroom	31.6	3.5	13	1.00	7.2	3.0	3.0	1097	3.6	5.1
Classroom	42.5	2.9	25	0.91	9.2	5.4	6.7	941	4.8	6.9
Classroom	56.5	2.9	25	0.90	8.9	3.9	4.9	962	3.8	5.4
reduced occ.	56.5	2.9	20	0.90	8.4	3.0	3.7	999	3.2	4.5
Large teaching space	129.5	2.9	50	0.60	13.3	5.1	6.4	776	3.4	4.9
reduced occ.	129.5	2.9	40	0.60	12.5	3.8	4.8	801	2.9	4.1
2-person office	21.0	2.6	2	1.00	4.9	0.5	0.6	1535	1.4	2.0
Open-plan office	56.7	2.6	6	0.80	16.5	1.7	2.4	736	1.4	2.1
Open-plan office	173.0	2.6	17	0.60	25.4	2.5	3.5	619	1.4	2.0
Meeting room	29.2	2.6	10	1.00	34.2	11.7	16.2	563	3.1	4.4
reduced occ.	29.2	2.6	6	1.00	30.3	6.2	8.6	584	2.1	3.1

In highlighted cases, EN 16798-1 PAQ ventilation rate is higher

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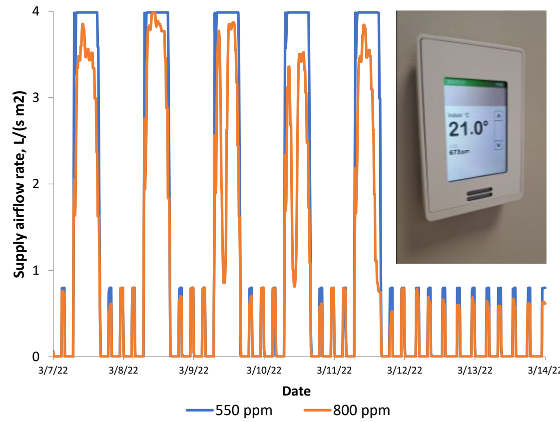
Operation for optimal indoor air quality - addressed in EN 16798-1 revision

Epidemic periods:

- CO_2 setpoint 550 ppm

Outside epidemic periods:

- operation according to perceived air quality design ventilation rate
- recommended CO_2 setpoints:
  - 800 ppm in classrooms and meeting rooms
  - 650 ppm in offices, restaurants, and gyms



Ventilation airflow rates in a typical classroom with CO_2 set point of 550 ppm and 800 ppm

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Conclusions

- EN 16798-1 revision proposes normative but selected-by-the-client design method for airborne transmission – not mandatory
- The method allows reverse engineering – max occupancy for epidemic periods can be calculated at given ventilation rate
- Stresses ventilation effectiveness: the issue of the point source / advanced air distribution solutions enable to reduce ventilation rates
- The aim is not to eliminate, but considerably reduce the infection risk: infector will cause no more than one new disease case during pre-symptomatic infectious period
- In typical classrooms and offices, infection risk-based ventilation rates mostly do not exceed Category I ventilation rates, ranging in classrooms 8-13 L/s per person
- In meeting rooms, restaurants and gyms, infection-risk based ventilation rates are remarkably high, indicating that feasible ventilation design would suggest to reduce occupancy and to use advanced air distribution

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