AIVC Workshop, May 2023, Tokyo

Revision of ISO17772-1 and EN16798-1 Standards Dealing with Indoor Environmental Quality

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International Standards
Indoor Environmental Quality

- EN16798-1 and ISO 17772-1:
- EN TR 16798-2 and ISO TR 17772:

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 16798-1

May 2019

ICS 91.120.10; 91.140.01

Supersedes EN 15251:2007

English Version

Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics - Module M1-6

DS/CEN/TR 16798-2:2019

TECHNICAL REPORT
RAPPORT TECHNIQUE
TECHNISCHER BERICHT

CEN/TR 16798-2

May 2019

ICS 91.120.10; 91.140.01

English Version

Energy performance of buildings - Ventilation for buildings - Part 2: Interpretation of the requirements in EN 16798-1 - Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics (Module M1-6)

Suggested procedure

- There is a need to revise ISO 17772-1 and -2 (foreseen as **ISO 52007**) in parallel to the revision in Europe of EN 16798-1.
  - CEN has decided not to do the revision through a Vienna agreement. It is however still important that the two standards do not conflict with each other.
- There is a wish to make a clearer distinction between the different parts; and therefore, have separate parts for Thermal Comfort, Indoor Air Quality, Lighting, Acoustic; but still as one standard.
- It is also important that the content is aligned to the existing structure and content of ISO17772

Committees involved

- ISO/TC 163 Thermal performance and energy use in the built environment
  - ISO/TC 163/WG 4 Joint ISO/TC 163 - ISO/TC 205 WG: Energy performance of buildings using holistic approach
- ISO/TC 205 Building environment design
  - ISO/TC 205/WG 3 Building Automation and Control System (BACS) Design
- ISO/TC 274 Light and lighting
  - ISO/TC 274/JWG 1 Energy performance of lighting in buildings (joint working group with CIE-JTC 6)
- ISO/TC 43/SC 2 Building acoustics

Structure for 52007

Document and title		Responsible Committee(s)
ISO 52007-1	**Overarching standard**	Overarching TC163/205JWG with members from TC274 and TC43/SC 2
ISO 52007-2	Technical Report	
ISO 52007-3	**Thermal Comfort**	Thermal Comfort TC163/205JWG
ISO 52007-4	Technical Report and Guidance for part 3	
ISO 52007-5	**Indoor Air Quality**	Indoor Air Quality TC163/205JWG
ISO 52007-6	Technical Report and Guidance for part 5	
ISO 52007-7	**Lighting**	TC 274/JWG 1 (- CIE JTC6) Collaboration route recommendation expected from the ISO/TC 274/JAG
ISO 52007-8	Technical Report and Guidance for part 7	
ISO 52007-9	**Acoustic**	TC 43/SC 2
ISO 52007-10	Technical Report and Guidance for part 9	

Categories

Category	Level of expectation
IEQ_I	**High**
IEQ_{II}	**Medium**
IEQ_{III}	**Moderate**
IEQ_{IV}	**Low**

- The categories are related to the level of expectations the occupants may have.
- A normal level would be “Medium”.
- A higher level may be selected for occupants with special needs (children, elderly, handicapped, etc.).
- A lower level will not provide any health risk but may decrease comfort.

Recommended thermal comfort categories for design of mechanical heated and cooled buildings

Category	Thermal state of the body as a whole	
	PPD %	Predicted Mean Vote
I	< 6	-0.2 < PMV < + 0.2
II	< 10	-0.5 < PMV < + 0.5
III	< 15	-0.7 < PMV < + 0.7
III	< 25	-1.0 < PMV < + 1.0

*Temperature ranges for **dimensioning** and hourly calculation of cooling and heating energy in three categories of indoor environment*

Type of building/ space	**Category**	**Operative Temperature for Energy Calculations** °C	
Offices and spaces with similar activity (single offices, open plan offices, conference rooms, auditorium, cafeteria, restaurants, class rooms, Sedentary activity ~1,2 met		**Heating (winter season), ~ 1,0 clo**	**Cooling (summer season), ~ 0,5 clo**
	I	**21,0 – 23,0**	**23,5 - 25,5**
	II	**20,0 – 24,0**	**23,0 - 26,0**
	III	**19,0 – 25,0**	**22,0 - 27,0**
	IV	**17,0 – 26,0**	**21,0 - 28,0**

Temperature ranges for dimensioning and hourly calculation of cooling and heating energy in four categories of indoor environment

Cat.	Heating season (1.0 clo) °C	Cooling season, (0.5 clo) °C
I	21.0 - 23.0	23.5 - 25.5
II	20.0 - 24.0	23.0 - 26.0
III	19.0 - 25.0	22.0 - 27.0
IV	17.0 - 25.0	21.0 - 28.0

- Temperature ranges consider for the four categories of indoor environment recommended for sedentary work (1.2 met) in ISO 17772-1.
- Air velocity is assumed below 0.1 m/s and the relative humidity is 40% for heating seasons and 60% for cooling seasons.

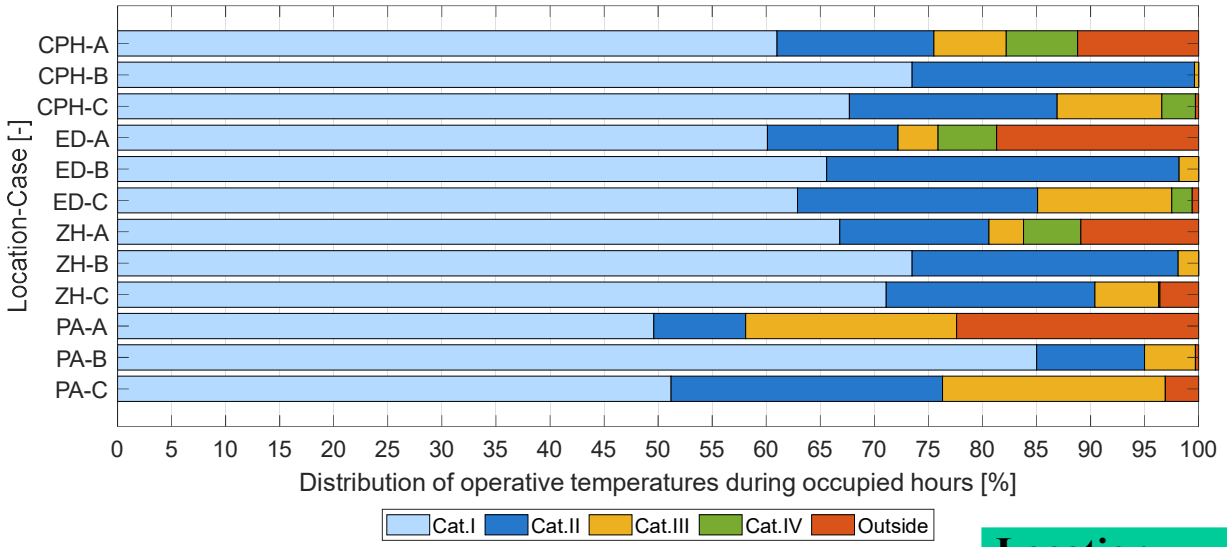
This will work for establishing design values for dimensioning of heating and cooling systems by using the lower value in heating season for the heating system and the upper value in cooling season for the cooling system.

Issues

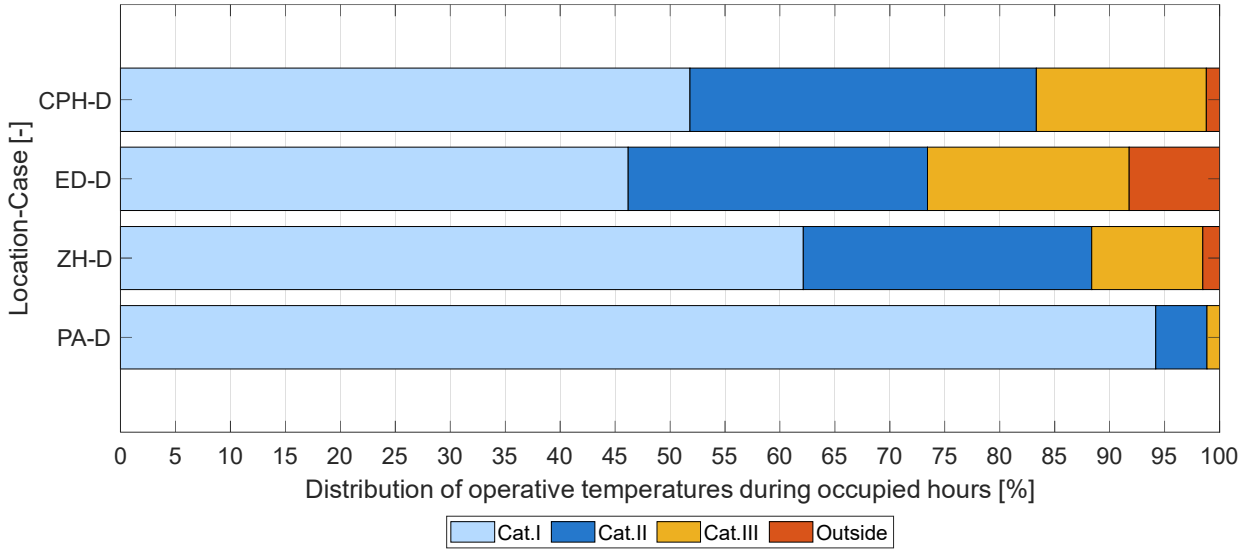
- The method do not explain what to do regarding room temperatures in shoulder seasons (spring, fall)
  - The standard recommends defining heating season when the outside running mean temperature is below 10 ^{o}C and cooling season when it is above 15 ^{o}C.
  - As comfort criteria for spring/fall you may use 0.75 clo or use the adapted model during those seasons

- No yearly Key Performance Indicator (KPI) for thermal comfort, while for energy you have one value kWh/m^2 per year
  - A KPI can be calculated based on the percentage of occupied hours inside the categories of indoor environmental quality defined in ISO 17772-1.
  - The score assigned weighted values for % time spent in each category, and provides a single value from 1 (Best) to 5 (Worst) equation (2)

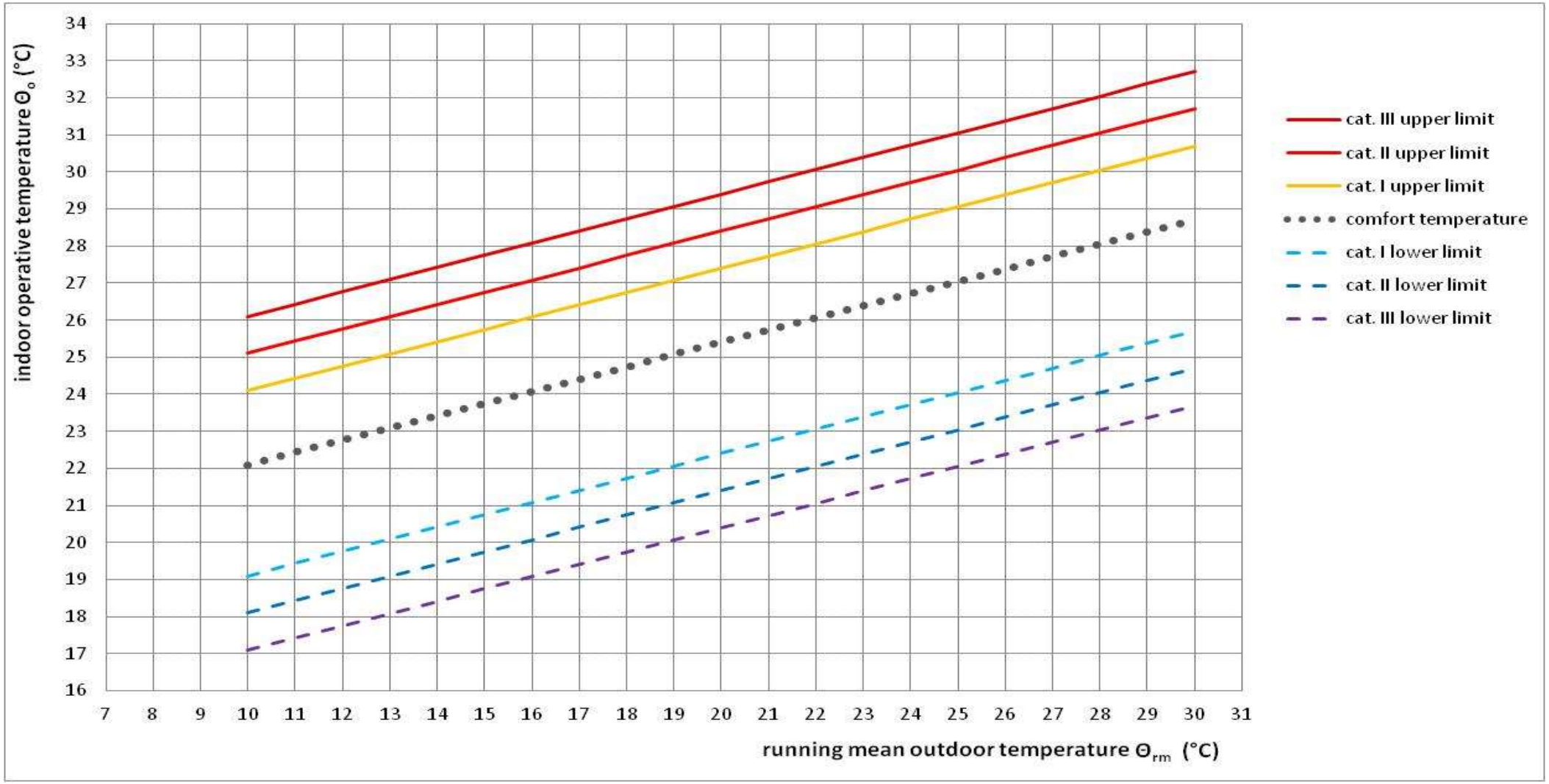
$$TCS = \%Cat.I * 1 + (\%Cat.II - \%Cat.I) * 2 + (\%Cat.III - \%Cat.II) * 3 + (\%Cat.IV - \%Cat.III) * 4 + \%outside * 5 \quad (2)$$



Location	CPH	ED	ZH	PA
TCS A	1.93	2.11	1.80	2.37
B	1.27	1.36	1.28	1.21
C	1.49	1.55	1.46	1.79
TCS D	1.71	2.00	1.56	1.10
ACM				



Adapted method in ISO17772-1



$$\Theta_{rm} = (\Theta_{ed\ -1} + 0{,}8\ \Theta_{ed\ -2} + 0{,}6\ \Theta_{ed\ -3} + 0{,}5\ \Theta_{ed\ -4} + 0{,}4\ \Theta_{ed\ -5} + 0{,}3\ \Theta_{ed\ -6} + 0{,}2\ \Theta_{ed\ -7})/3{,}8$$

- activity levels lie most of the time in the range of 1,2 - 1,6 met
- clothing insulation can be varied according to momentary preferences from 0,5 to 1,0 clo
- access to operable windows
- less than 4 persons per room
- such as dwellings and office buildings.

Issues-Adapted Method

- When to use adapted method is still unclear
- What to do in mixed-mode buildings?

CRITERIA FOR INDOOR AIR QUALITY ~VENTILATION RATES

COMFORT (Perceived Air Quality)

HEALTH

PRODUCTIVITY

ENERGY

~~Cross contamination~~

Indoor Air Quality

- Design parameters for indoor air quality shall be derived using one or more of the following methods:

1. Method 1: Method based on perceived air quality;
2. Method 2: Method using limit values for individual substances
3. Method 3: Method based on predefined ventilation air flow rates.

Concept for calculation of design ventilation rate
Method 1

People Component

Building Component

Breathing Zone Outdoor Airflow

$$V_{bz} = R_p P_z + R_a A_z$$

Minimum l/s/Person

Number of People

Building Area

Minimum l/s/m²

Basic required ventilation rates for diluting emissions (bio effluents) from people for different categories

Category	Expected Percentage Dissatisfied	Airflow per non-adapted person l/(s.pers)
I	15	10
II	20	7
III	30	4
IV	40	2,5*

*The total ventilation rate must never be lower than 4 l/s per person

ASHRAE Standard 62.1 : Adapted persons 2,5 l/s person (Cat. II)

Design ventilation rates for diluting emissions from buildings

Category	Very low polluting building l/(s m^2)	Low polluting building l/(s m^2)	Non low-polluting building l/(s m^2)
I	0,5	1,0	2,0
II	0,35	0,7	1,4
III	0,2	0,4	0,8
IV	0,15	0,3	0,6
Minimum total ventilation rate for health	4 l/s person	4 l/s person	4 l/s person

Example on how to define low and very low polluting buildings

SOURCE	Low emitting products for low polluted buildings	Very low emitting products for very low polluted buildings
Total VOCs TVOC (as in CEN/TS 16516)	< 1.000 µg/m³	< 300 µg/m³
Formaldehyde	< 100 µg/m³	< 30 µg/m³
Any C1A or C1B classified carcinogenic VOC	< 5 µg/m³	< 5 µg/m³
R value (as in CEN/TS16516)	< 1.0	< 1.0

Issues

- Need for better emission data for building materials, furniture etc.
- Difficult to estimate what building type you have

Total ventilation rate

$$q_{tot} = n \cdot q_p + A_R \cdot q_B$$

$$q_{supply} = q_{tot} / \varepsilon_v$$

- Where
- ε_v = the ventilation effectiveness (EN13779)
- q_{supply} = ventilation rate supplied by the ventilation system
- 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, pers
- A_R= room floor area, m^2
- q_B = ventilation rate for emissions from building, l/s,m^2

Example of design ventilation air flow rates for a single-person office of 10 m^2 in a low polluting building (un-adapted person)

Cate-gory	Low-polluting building l/(s*m^2)	Airflow per non-adapted person l/(s*person)	Total design ventilation air flow rate for the room		
			l/s	l/(s*person)	l/(s* m^2)
I	1,0	10	20	20	2
II	0,7	7	14	14	1,4
III	0,4	4	8	8	0,8
IV	0,3	2,5	5,5	5,5	0,55

Design ventilation rates

Type of building or space	Category	Floor area m²/person	q_p minimum ventilation rate		q_B	q_{tot}		q_B	q_{tot}		q_B	q_{tot}	
			l/(s m²)	l/s pers.	l/s, m²	l/s, m²	l/s,pers	l/s, m²	l/s, m²	l/s,pers	l/s, m²	l/s, m²	l/s,pers
			for occupancy only		for very low-polluted building			for low-polluted building			for non-low-polluted building		
Single office	I	10	1	10	0,5	1,5	15	1	2,0	20,0	2	3,0	30
	II	10	0,7	7	0,35	1,1	11	0,7	1,4	14,0	1,4	2,1	21
	III	10	0,4	4	0,2	0,6	6	0,4	0,8	8,0	0,8	1,2	12
	IV	10	0,25	2,5	0,15	0,4	4	0,3	0,6	5,5	0,6	0,9	9
Landscaped office	I	15	0,7	10	0,5	1,2	18	1	1,7	25,0	2	2,7	40
	II	15	0,5	7	0,35	0,8	12	0,7	1,2	17,5	1,4	1,9	28
	III	15	0,3	4	0,2	0,5	7	0,4	0,7	10,0	0,8	1,1	16
	IV	15	0,2	2,5	0,15	0,3	5	0,3	0,5	7,0	0,6	0,8	12
Conference room	I	2	5	10	0,5	5,5	11	1	6,0	12,0	2	7,0	14
	II	2	3,5	7	0,35	3,9	8	0,7	4,2	8,4	1,4	4,9	10
	III	2	2	4	0,2	2,2	4	0,4	2,4	4,8	0,8	2,8	6
	IV	2	1,25	2,5	0,15	*(1,4) 1,8*	*(3) 4*	0,3	*(1,6) 2*	*(3,1) 4*	0,6	1,9	4

Type of building/ space	Occu-pancy person/m^2	Cate-gory CEN	Occupants only l/s person		Additional ventilation for building (add only one) l/s·m^2			Total l/s·m^2	
			ASH-RAE Rp	CEN	CEN low-polluting building	CEN *Non*-low-polluting building	ASH-RAE Ra	CEN Low Pol.	ASH-RAE
Single office (cellular office)	0,1	A	2,5	10	1,0	2,0	0,3	2	0,55
		B		7	0,7	1,4		1,4	
		C		4	0,4	0,8		0,8	
Land-scaped office	0,07	A	2,5	10	1,0	2,0	0,3	1,7	0,48
		B		7	0,7	1,4		1,2	
		C		4	0,4	0,8		0,7	
Confe-rence room	0,5	A	2,5	10	1,0	2,0	0,3	6	1,55
		B		7	0,7	1,4		4,2	
		C		4	0,4	0,8		2,4	

1 l/s m^2 = 0.2 cfm/ft^2

HEALTH CRITERIA FOR VENTILATION
ISO 17772-1 and prEN16798-1

Minimum 4 l/s/person

Specific Pollutants-Method 2

The ventilation rate required to dilute a pollutant shall be calculated by this equation:

$$Q_h = \frac{G_h}{C_{h,i} - C_{h,o}} \cdot \frac{1}{\varepsilon_v} \qquad \text{Eq (2)}$$

where:

- Q_h is the ventilation rate required for dilution, in litre per second;
- G_h is the pollution load of a pollutant, in micrograms per second;
- $C_{h,i}$ is the guideline value of a pollutant, see Annex B6 , in micrograms per m^3;
- $C_{h,o}$ is the supply concentration of pollutants at the air intake, in micrograms per m^3;
- ε_v is the ventilation effectiveness

NOTE. $C_{h,i}$ and $C_{h,o}$ may also be expressed as ppm (vol/vol). In this case the pollution load G_h has to be expressed as l/s.

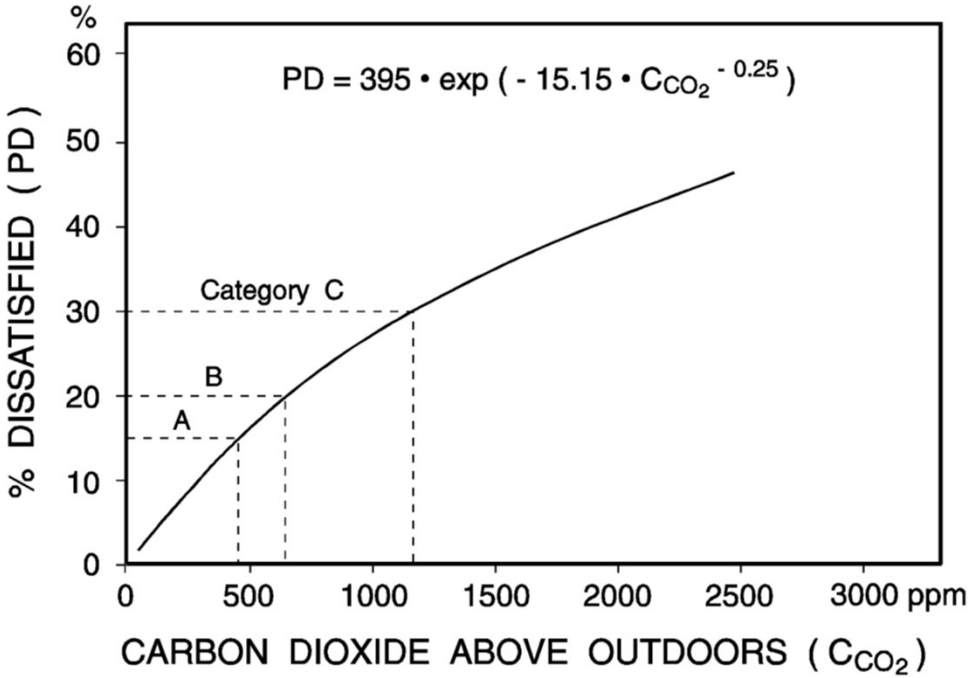
Pollutant	WHO Indoor Air Quality guidelines 2010	WHO Air Quality guidelines 2005
Benzene	No safe level can be determined	-
Carbon monoxide	15 min. mean: 100 mg/m^3 1h mean: 35 mg/m^3 8h mean: 10 mg/m^3 24h mean: 7 mg/m^3	-
Formaldehyde	30 min. mean: 100 µg/m^3	-
Naphthalene	Annual mean: 10 µg/m^3	-
Nitrogen dioxide	1h mean: 200 µg/m^3 Annual mean: 40 mg/m^3	-
Polyaromatic Hydrocarbons (e.g. Benzo Pyrene A B[a]P)	No safe level can be determined	-
Radon	100 Bq/m^3 (sometimes 300 mg/m^3, country-specific)	-
Trichlorethylene	No safe level can be determined	-
Tetrachloroethylene	Annual mean: 250 µg/m^3	
Sulfure dioxide	-	10 min. mean: 500 µg/m^3 24h mean: 20 mg/m^3
Ozone	-	8h mean:100 µg/m^3
Particulate Matter PM 2,5	-	24h mean: 25 µg/m^3 Annual mean: 10 µg/m^3
Particulate Matter PM 10	-	24h mean: 50 µg/m^3 Annual mean: 20 µg/m^3

WHO guidelines values for indoor and outdoor air pollutants

There is a need for health/comfort criteria for other substances

Particles must be included in the standard

CO_2 as reference not consistent with Method 1



Category	Corresponding CO_2 concentration above outdoors in PPM for non-adapted persons
I	550 (10)
II	800 (7)
III	1 350 (4)
IV	1 350 (4)

Table B2.5 - Example of equivalent increase in CO_2 levels indoor for the total ventilation rates specified in Table B2.3

Type of building or space	Category	occupancy	ΔCO_2 [ppm]		
		person/m^2	Very low-polluting	low-polluting	Not low-polluting
Single office	I	0,1	370	278	185
	II	0,1	529	397	265
	III	0,1	926	694	463
	IV	0,1	1389	1010	654
Land-scaped office	I	0,07	317	222	139
	II	0,07	454	317	198
	III	0,07	741	556	347
	IV	0,07	1235	794	483
Conference room	I	0,5	505	463	397
	II	0,5	722	661	567
	III	0,5	1263	1157	992
	IV	0,5	*1462*	*1389*	1502
Auditorium	I	1,33	535	517	483
	II	1,33	765	738	690
	III	1,33	1347	1300	1208
	IV	1,33	*1576*	*1398*	*1576*

Issues

- Target CO_2 concentration should correctly be set as difference between inside and outside
- Target CO_2 concentration for the same level of air quality depends on occupant density
- Should we allow to use a dynamic formular for individual substances (meeting rooms, class rooms, etc.)
- If air cleaning technologies are used and partly substituting for outside air the resulting room concentration of CO2 will be higher for the same level of air quality.

Cat.	Method 2 CO_2 above outdoors PPM (l/s*pers.)	Method 1 Single office Low-pol. building CO_2 above outdoors PPM (l/s*pers.)
I	550 (10)	278 (20)
II	800 (7)	397 (14)
III	1350 (4)	694 (8)
IV	1350 (4)	1010 (5.5)

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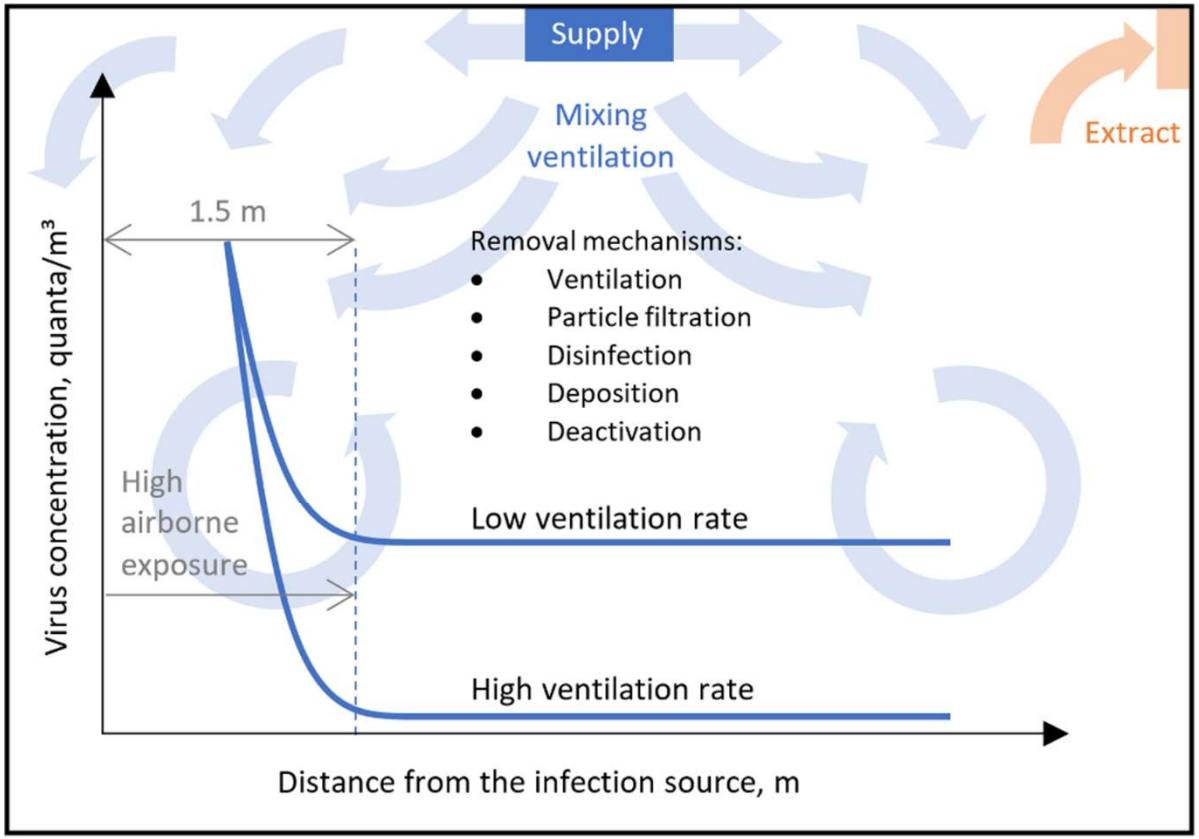
Risk-based ventilation design

Respiratory infection risk-based ventilation design method

Jarek Kurnitski [a,b], Martin Kiil [a,*], Pawel Wargocki [c], Atze Boerstra [d,e], Olli Seppänen [f], Bjarne Olesen [c], Lidia Morawska [g,h]



Ventilation rate equation at given probability

Assuming steady state and substituting C_{avg} and E, and considering that outdoor air ventilation rate $Q = \lambda_v V$ results:

$$p = 1 - e^{-\frac{(1-\eta_i) I q \quad _b (1-\eta_s) \mathrm{D}}{Q + (\lambda_{dep} + k + k_f) V}}$$

- Solving this equation for outdoor air ventilation rate Q (m^3/h) gives

$$Q = \frac{(1-\eta_i) I q Q_b (1-\eta_s) \mathrm{D}}{\ln\left(\frac{1}{1-p}\right)} - (\lambda_{dep} + k + k_f) V$$

- (masks and air cleaner included)

https://www.researchgate.net/publication/350111147_Preprint_-A_new_ventilation_criterion_based_on_respiratory_infection_risk_of_COVID-19

Example criteria for personalized systems

Aspect	Requirement
'Temperature' control winter	At workstation level, the (operative/equivalent) temperature is adjustable with a response speed of at least 0,5 K/minute within a range of 5 K, from 18 °C to 23 °C.
'Temperature' control summer	At workstation level, the (equivalent) temperature is adjustable (with a response speed of at least 0,5 K/minute within a range of 5 K, from 22 °C to 27 °C.
Fresh air supply control	Local fresh air supply (per workstation) is adjustable from around 0 to at least 7 l/s.
Delivered air quality	For requirements related to air cleaning technology: see Annex K.
Installation noise	Noise level – with the personalized system in the highest setting – should not be higher than 35 dB(A).

This is a topic under IEA -EBC Annex 87 "PECS"

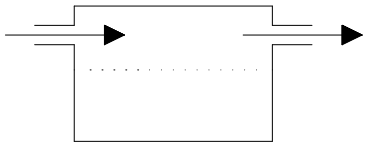
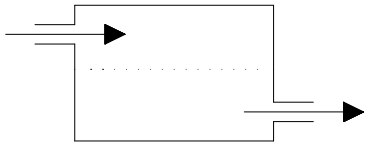
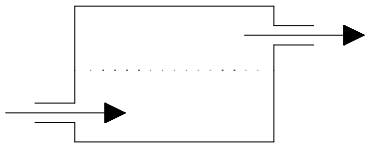
Air Distribution Effectiveness

$$\varepsilon_V = \frac{C_E - C_S}{C_I - C_S}$$

Concentrations:

- C_E **exhaust air**
- C_S **supply air**
- C_I **breathing zone**

CEN Report CR 1752 (1998)

Mixing ventilation		Mixing ventilation		Displacement ventilation		Personalized ventilation	
							
T supply - T inhal °C	Vent. effect. -	T supply - T inhal °C	Vent. effect. -	T supply - T inhal °C	Vent. effect. -	T supply - T room °C	Vent. effect. -
< 0	0,9 - 1,0	< -5	0,9	<0	1,2 - 1,4	-6	1,2 - 2,2
0 - 2	0,9	-5 - 0	0,9 - 1,0	0-2	0,7 - 0,9	-3	1,3 - 2,3
2 - 5	0,8	> 0	1	>2	0,2 - 0,7	0	1,6 - 3,5
> 5	0,4 - 0,7						

Issues-PECS

- No. available test standard
- Must be designed/dimensioned for a more narrow temperature range
- How much can you relax requirements to the ambient system?
- Issues are part of EBC-IEA Annex 87

ISSUES for REVISION

- Not consistent requirements based on CO_2
- Need to include criteria for particles
- Need criteria for substances not included in WHO guideline
- Demand Control Ventilation based on CO_2 requires different set-points:
  - Influenced by occupant density
  - If required ventilation is partly substituted by air cleaning
- Ventilation and cross contamination (pandemic, flue, etc.)
- Personalized Environmental Control Systems (personalized ventilation)
- More focus on ventilation efficiency
- KPI’s for yearly performance

Thank You

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