Indoor Environmental Quality – Revision of standard EN16798-1/2 in relation to the EPBD guidline

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International Standards for Indoor Environmental Quality(IEQ)

- 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)

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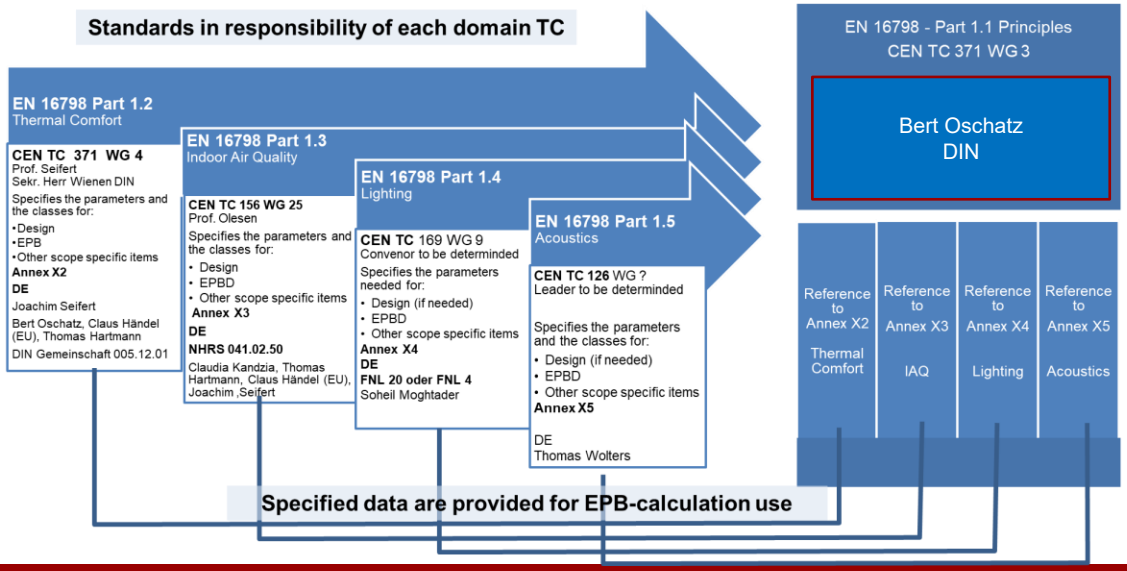
Timeline of the Revision

Revision EN 16798-1 Energy Performance of Buildings – Indoor Environmental Parameters



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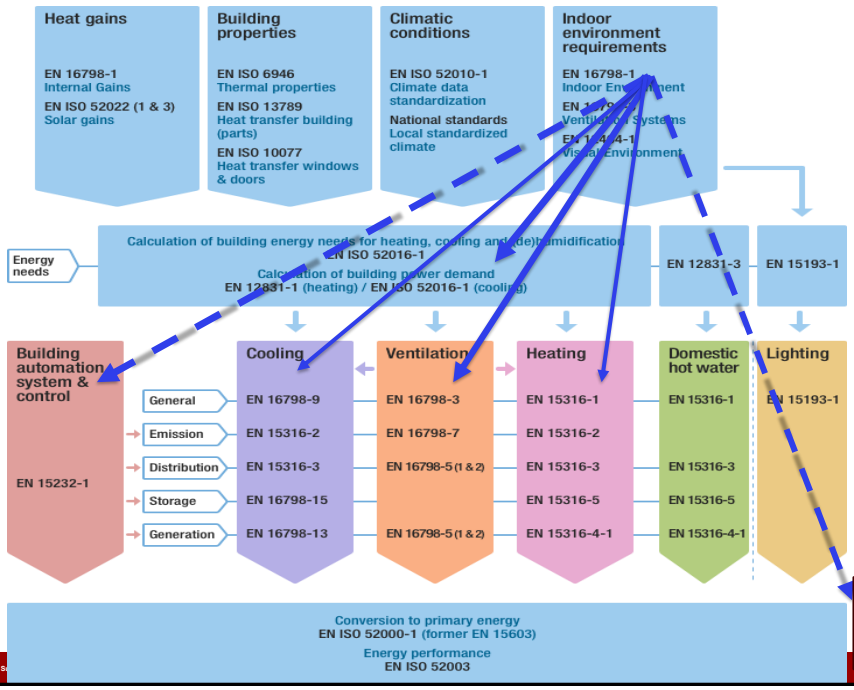

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Categories in CEN 16798-1

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.

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EPBD GuidelineReferences for indoor environmental quality requirements

- In order to set relevant IEQ requirements, Member States can refer to the parameters introduced in the EN 16798-1 standard, describing the occupant expectation towards IEQ through Categories I to IV.
- The European framework for sustainable buildings – Level(s) – can also supplement the standard[42].
- Another example of IEQ indicators for buildings undergoing renovation is TAIL[43]
- For new buildings, where 'optimal' IEQ is mentioned, it is recommended that Member States use the Category II specified in EN 16798-1 (medium occupant expectation), whose values ensure the comfort and well-being of occupants and limit adverse health effects.
- The values in Table 11, mostly based on Category II of EN 16798-1, can constitute a useful reference for Member States
- For adequate indoor environmental quality standards in buildings to ensure a healthy indoor climate (i.e. for existing buildings in operation), in line with Article 13(4), Member States may refer to Category III, based on moderate occupant expectation.
- Requirements may be tightened according to special requirements linked to the use of specific buildings (e.g. occupants with special needs such as children, older people, people with disabilities, etc.).

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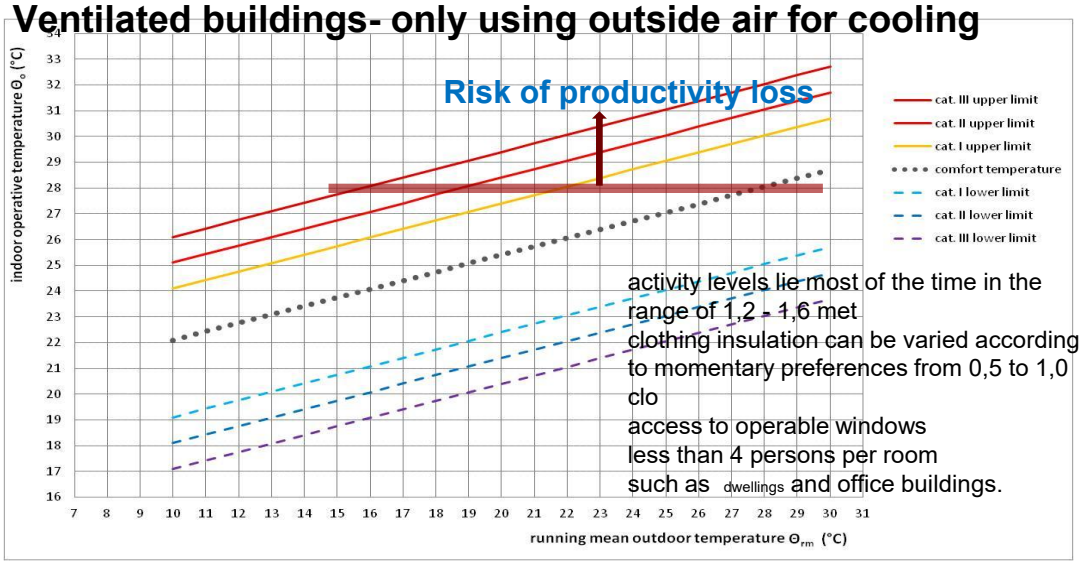
Recommended thermal comfort categories for design of heated and cooled buildings

Category	Thermal state of the body as a whole		Heating season (winter) 1 clo	Cooling season (summer) 0.5 clo
	PPD %	PMV	Operative temperature range °C	Operative temperature range °C
I	< 6	-0,2 < PMV < + 0,2	21,0 – 23,0	23,5 – 25,5
II	< 10	-0,5 < PMV < + 0,5	20,0 – 24,0	23,0 – 26,0
III	< 15	-0,7 < PMV < + 0,7	19,0 – 25,0	22,0 – 27,0
IV	< 25	-1,0 < PMV < + 1,0	17,0 – 25,0	21,0 – 28,0

Recommended temperature ranges for the four categories of indoor environment recommended for sedentary work (1.2 met) in ISO 16798-1. Air velocity is assumed below 0.1 m/s and the relative humidity is 40% for heating seasons and 60% for cooling seasons.

EN16798-1 and ISO 17772-1 Adapted approach

Ventilated buildings- only using outside air for cooling



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

METHODS-IAQ-VENTILATION

- Ventilation Rate Procedure
  - Method 1 Perceived Air Quality
  - Method 2 Individual substances-mass balance
  - Method 3 Prescriptive Table
- Indoor Air Quality (IAQ) Procedure:
  - Building simulation
- Airborne Contaminant Control

Concept for calculation of design ventilation rate according to EN16798-1 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

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 (EN16798-3/4)
- 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

Perceived air quality
Un-adapted persons

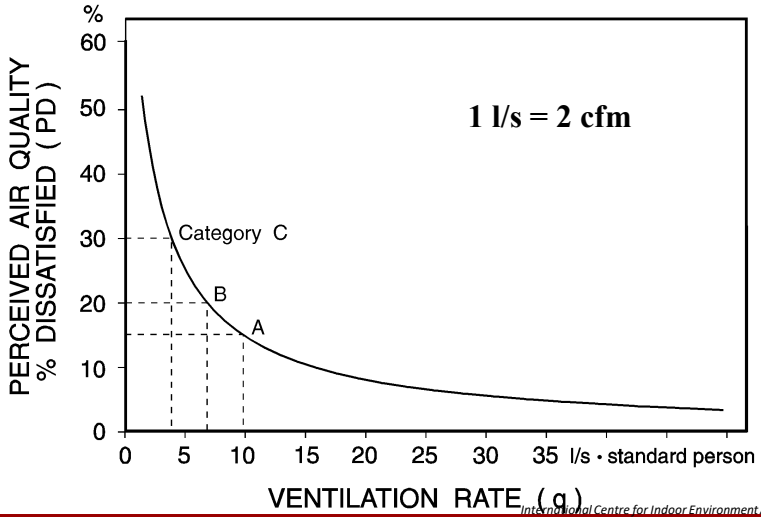


Diagram based on studies with Danish subjects (Fanger et.al).

Similar results obtained by North-American subjects (Cain et.al.)

Similar results obtained with Japanese subjects (Tanabe)

Concept for calculation of design ventilation rate EN 16798-1, Method 1

Table 1: Design ventilation rates for non-adapted persons for diluting emissions (bio effluents) from people and for buildings for different categories

		People component, q_p	Building Component, q_B		
Indoor Environmental Category	Expected Percentage Dissatisfied %	Airflow per non-adapted person l/(s.pers)	Very low polluting building l/(s m^2)	Low polluting building l/(s m^2)	Non low polluting building l/(s m^2)
IEQ_I	15	10	0,5	1,0	2,0
IEQ_{II}	20	7	0,35	0,7	1,4
IEQ_{III}	30	4	0,2	0,4	0,8
IEQ_{IV}	40	2,5	0,15	0,3	0,6

Design ventilation rates

Type of building or space	Category	Floor area m^2/person	q_p minimum ventilation rate		q_B	q_{tot}		q_B	q_{tot}		q_B	q_{tot}	
			l/(s m^2)	l/s pers.	l/s, m^2	l/s, m^2	l/s,pers	l/s, m^2	l/s, m^2	l/s,pers	l/s, m^2	l/s, m^2	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

HEALTH CRITERIA FOR VENTILATION
Minimum 4 l/s/person

In EN16798-1/2 revision:
Increased ventilation during Pandemic
Reducing cross contamination

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.

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/m²	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*

Prescriptive Design ventilation rates: Method 3-table

Type of building or space	Category	Floor area m²/person	q_p	q_p	q_B	q_{tot}		q_B	q_{tot}		q_B	q_{tot}	
			minimum ventilation rate										
			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

Air Cleaning

- Air filtration refers to EN16798-3/4
- Gas Phase Air Cleaning
  - CADR (Clean Air Delivery Rate), Method 1
    - New Test Method (ISOTC142WG8)
  - Individual Substances, Method 2
    - Existing test methods
  - IAQ-Procedure

Indoor Air Quality Procedure

- Building Simulations
  - Whole building
  - Ventilation System
  - Air Cleaning
  - Fictive building emissions
  - Health/well-being criteria for individual substances

Relevant IEQ parameters and examples of optimal IEQ conditions

- Table 11 (page 25) provides examples of **optimal IEQ reference values and ranges** in design outdoor conditions, that Member States may use for new buildings. The values in this table are mostly based on Category II of EN 16798-1, based on a medium expectation of occupants

	Parameter	Examples of optimal ranges	Deviation during occupancy for design outdoor conditions
Air quality	Ventilation rate (q) (a)	Supply air flow rate, $q = q_p \cdot n + q_b \cdot A$, where A is the area of the space, q_p is 7 l/s per person for *non-adapted* and 2.5 l/s per person for *adapted*, and q_b is 0.7 l/s per m² (non-residential) (b) and 0.15 l/s per m² (residential) (c). Extract air flow rates: 15 l/s for bathroom/toilet, 10 l/s for kitchen, and 10 l/s for other wet room. A 75% odour extraction from cooking hoods is considered as optimum for boost air flow rate from kitchen hoods (EN 13141-3)	5%
	Carbon dioxide	$\Delta CO_2 \leq 800$ ppm above outdoor CO_2 concentration, if people are the main source of pollution (d) (EN 16798)	5% (f)
	$PM_{2.5}$ (m)	Below an annual mean of 10 µg/m³ and a 24-hour mean of 25 µg/m³	Dependent on outdoor concentration and human behaviour
	Formaldehyde (m)	30-minute mean: 100 µg/m³	
	Nitrogen dioxide (m)	1 h mean: 200 µg/m³; Annual mean: 40 µg/m³	
	Radon (m)	Reference level of 100 Bq/m³ (or 300 Bq/m³ depending on prevailing country-specific conditions)	
	Carbon monoxide (m)	15-minute mean: 100 mg/m³; 1 h mean: 35 mg/m³; 8 h mean: 10 mg/m³; 24 h mean: 4 mg/m³	

Table 10 (page 23) provides examples of **relevant IEQ parameters** when setting **design requirements** (e.g. in line with Articles 7(6) and 8(3)), **conducting commissioning**, **performing monitoring** (e.g. in line with Article 13(5)), and **conducting inspections** (in line with Article 23).

	Indicator	D	C	M(*)	I(*)	Description and references
Indoor air quality	Ventilation rate	X	X		X	To be addressed as part of system inspections pursuant to Article 23. Supply or removed air from space for the purpose of controlling air contaminant levels, humidity, perceived air quality or temperature within the space (EN 16798-1). If critical sources for health are identified, it must be checked that they remain below the health threshold values. Minimum 4 l/s per person is prescribed during occupied hours; 0.15 l/s per m² during unoccupied hours. Typically measured from supply and extract terminals.
	Carbon dioxide	X		X		Proxy for ventilation effectiveness in spaces where people are the main source of pollution. Indoor CO_2 concentration should be adjusted according to the outdoor CO_2 concentration. It should not exceed 1350 ppm above outdoor concentration. Typically measured in extract terminals. (EN 16798).
	$PM_{2.5}$	X(e)		X(d)		Particulate matter where particles have an aerodynamic diameter equal to or less than 2.5 µm. It can be generated indoors from combustion appliances or outdoors and has harmful effects on human health. Air filtration is required to control particulate matter from outdoor sources. Indoor particulate matter is controlled by reducing emission sources (e.g. electric instead of gas stoves) and adequate ventilation. Preferably below an annual mean of 10 µg/m³. Incremental steps are proposed for $PM_{2.5}$ limits (35, 25, 15, 10, 5 µg/m³) (EN 16798-1, WHO).
	Formaldehyde (e)	X(f)				Major sources are building materials and consumer products (e.g. furniture, cleaning). It can cause sensory irritation and respiratory health risks. Use of labelled low-emitting building and finishing materials and products can reduce exposure Measured near potential sources such as furniture and flooring (EN 16798-1, WHO).
	Nitrogen dioxide	X(f)				Originating from combustion. Indoor contamination may be possible from attached garages and indoor combustion sources, in which cases sensors and/or measuring requirements would be recommended. It poses health risks related to the respiratory system. Measured near potential sources such as kitchens and garages. A 1 h mean limit of 200 µg/m³ and annual mean of 40 µg/m³ are proposed (EN 16798-1, WHO).
	Radon	X(f)				Human carcinogen, originating from decay of radium in soil and rocks. Reference level of 100 Bq/m³ (or 300 Bq/m³ based on prevailing country-specific conditions). Measured in the lowest occupied level of the building (EN 16798-1, WHO).
	Carbon monoxide	X(f)				Originating from combustion. Acute exposure-related reduction of exercise tolerance and increase in symptoms of ischaemic heart disease. A 24-hour mean limit of 4 mg/m³ is proposed with an interim target of 7 mg/m³ (EN 16798-1, WHO).

Why not ventilation rate for monitoring

Airborne Contaminant Control (Optional)

- Calculate the recommended ventilation during a pandemic
  - Not very accurate due to assumptions not well-documented
  - Alternative reduced the number of occupants
- Calculate the reduction of relative risk by increased ventilation
  - A relative measure, more accurate

IEQ-Assessment methods in informative annex

- TAIL (Temperature-Acoustic-IAQ-Lighting)
  - A method called "TAIL" was developed i an EU-Project. TAI rating is based on the levels of twelve parameters characterizing IEQ, which are measured modelled, or inspected in actual building
  - To allow the prediction of TAIL parameters during design, a method was developed called PredicTAIL.
  - Both TAIL and PredicTAIL allow evaluation of IEQ during design and operation. It uses distribution in categories for individual IEQ parameters representing thermal comfort, air quality, lighting, noise and calculate a yearly category (value) based on the method above for each parameter.

	IEQ parameter	Measured	Modelled	Visual inspection
T	Indoor temperature (°C)	×		
A	Noise level (dB(A))	×		
I	CO_2 (ppm)	×		
	Ventilation rate (L/s)	×		
	Formaldehyde (µg/m³)	×		
	Benzene (µg/m³)	×		
	$PM_{2.5}$ (µg/m³)	×		
	Radon (Bq/m³)	×		
	Indoor air relative humidity (%)	×		
	Visible mold (cm²)			×
L	Daylight factor (%)		×	
	Illuminance (lux)	×		

IEQ-Assessment methods in informative annex

DALY (Disability Adjusted Lost Years)

Method that integrates several parameters, where you calculate the effects of different IEQ parameter on health and “lost years”.

The knowledge on the health impact of IEQ parameters are still limited.

Even if there are data for the influence of many IAQ parameters, 80-90% is based on particle concentrations.

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One DALY represents the loss of the equivalent of one year of full health.
DALYs for a disease or health condition are the sum of the years of life lost to due to premature mortality (YLLs) and the years lived with a disability (YLDs) due to prevalent cases of the disease or health condition in a population.

Source: image by Planemad on Wikipedia

SUMMARY

- In the EPBD member states must in 2026 include requirements to Indoor Environmental Quality in their building regulations.
- The EPBD recommends to base requirements on EN 16798-1/2
- To fulfil new requirements in the EPBD regarding operation/control and assessment EN 16798-1/2 is now under revision
- A new version is expected during 2028-29