Indoor environmental input parameters for the design and assessment of energy performance of buildings

Olesen, Bjarne W.

Published in:
REHVA Journal

Publication date:
2015

Document Version
Publisher's PDF, also known as Version of record

Indoor environmental input parameters for the design and assessment of energy performance of buildings

The first international standard that dealt with all indoor environmental parameters (thermal comfort, air quality, lighting and acoustic) was published in 2007 as EN15251. This standard prescribed input parameters for design and assessment of energy performance of buildings and was a part of the set of standards developed to support the implementation of the Energy Performance of Buildings Directive in Europe. The standard has now been revised and issued for public comments with a new number: prEN16798-1.

BJARNE W. OLESEN
Ph.D. Fellow REHVA and ASHRAE, Professor
International Centre for Indoor Environment and Energy,
Department of Civil Engineering,
Technical University of Denmark
bwo@byg.dtu.dk

Besides the standard, a Technical Report 16798-2 is also being developed to support and explain the standard in more details. The standard is now written in normative language and should be clearer as all the informative text will be included in the technical report. The standard does include default criteria in 3-4 categories (**Table 1**) for the indoor environmental parameters, as described in this paper. It is however in a series of tables in an informative annex B. Individual countries can decide if they want to use these default values, only use one category, or use quite different values, which will be included in a normative national annex A with similar structure as annex B.

It is important to emphasis that the requirements and default criteria are based on the influence on the occupants and the standard do not set direct criteria depending on the type of system (mechanical or non-mechanical) used for conditioning the space.

Table 1. Description of the applicability of the categories used.

Category	Explanation
I	High level of expectation and also recommended for spaces occupied by very sensitive and fragile persons with special requirements like some disabilities, sick, very young children and elderly persons, to increase accessibility.
II	Normal level of expectation
III	An acceptable, moderate level of expectation
IV	Low level of expectation. This category should only be accepted for a limited part of the year

The draft technical report TR16798-2 will include guidance to the standard in similar sections as the standard. The TR includes also some additional sections and annexes with more voluntary concepts and methods as described in this paper.

In parallel two similar documents ISO-CD17772 and ISO-DTR17772 are being developed as almost identical documents. At a later stage it may be possible to combine these standards to one EN-ISO standard. The entire mentioned document will be available for comments during the first couple of months in 2015.

In the following section some of the highlights and especially what is new will be described.

Thermal Environment

The sections for thermal environment are almost identical to the existing standard. Criteria for both mechanical and non-mechanical heated, cooled and ventilated buildings are included. An addition is the criteria for local thermal discomfort based on EN ISO 7730 including draught, vertical air temperature differences, and radiant thermal asymmetry and floor surface temperatures. These criteria do not influence the calculation of energy performance; but will influence the design of the building and heating, cooling, and ventilation systems.

In the standard personalized systems have been introduced as a new part; but without any default criteria. However an annex in the TR gives some examples on how criteria for personalized systems could be expressed (see **Table 2**).

Table 2. 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 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 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).

Air Quality

The standard does include some new aspects related to indoor air quality. Like in the existing standard the requirements to indoor air quality is mainly expressed as a required minimum ventilation rate. The general requirements for the designer regarding the indoor air quality is the same for residential and non-residential buildings.

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

- Method based on perceived air quality
- Method using criteria for pollutant concentration
- Method based on pre-defined ventilation air flow rates

Within each method, the designer shall choose between different categories of indoor air quality and define which building category is to be used. The method used shall be documented and it must be explained why the selected method is appropriate.

Method based on perceived air quality

The total ventilation rate for the breathing zone is found by combining the ventilation for people and building calculated from the following formula.

$$q_{tot} = n \cdot q_p + A_R \cdot q_B \qquad \text{Eq (1)}$$

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·per person
A_R = floor area, m²
q_B = ventilation rate for emissions from building, l/s per m²

The basic tables with default values are **Table 3** and **Table 4**. The perceived air quality levels are set for non-adapted persons. If in special cases the design will include adapted persons see TR16798-2. A new criteria is that the total ventilation rate must never be lower than 4 l/s per person.

A building is by default a low-polluting building unless prior activity has resulted in pollution of the building (e.g. smoking). In this case, the building shall be regarded as non-low polluting. The category very low-polluting

Table 3. Design ventilation rates for non-adapted persons for diluting emissions (bioeffluents) from people for different categories.

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

* Category IV is intended for the evaluation of IAQ in existing buildings where the space for installations are limited.

Table 4. Design ventilation rates for diluting emissions from different type of buildings.

Category	Very low polluting building l/s per m²	Low polluting building l/s per m²	Non low-polluting building l/s per m²
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 per person	4 l/s per person	4 l/s per person

requires that the majority of building materials used for finishing the interior surfaces meet the national or international criteria of very low-polluting materials. An example of how to define very low-polluting building materials is given in Annex B3 of the standard.

The technical report will show tables with default values based on the two tables above and an assumed density of occupants. An example is given here in **Table 5**.

As mentioned above the technical report is also discussing a possible design for adapted persons i.e. persons that have occupied the space for more than 15 minutes and then adapted to the odour level of bioeffluent from the occupants. This may be relevant for spaces like conference rooms and auditorium, where people enter at the same time. The odour level will increase (perceived air quality decrease); but at the same time the occupants adapt to the odour level in the space and the lower ventilation and level of perceived air quality acceptable. This is as example the basis for the minimum ventilation rates given in ASHRAE standard 62.1. In the present standard prEN16798-1 the criteria of a total ventilation of minimum 4 l/s person must be fulfilled. It can be seen in **Table 5** that only in a few cases the criteria of 4 l/s person will be used and only for category 4. On the other hand if the ventilation rate is designed for adapted occupants the criteria of minimum 4 l/s person is used in all cases except for Category I. The values in italics indicate situations where the calculated ventilation rate is lower than the minimum value of 4 l/s per person required for health.

Method using criteria for pollutant concentration

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 = the ventilation rate required for dilution, in litre per second;

G_h = the pollution load of a pollutant, in micrograms per second;

$C_{h,i}$ = the guideline value of a pollutant, see Annex B6 , in micrograms per m³;

$C_{h,o}$ = the supply concentration of pollutants at the air intake, in micrograms per m³;

ε_v = the ventilation effectiveness

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

To calculate the design ventilation air flow rate from Eq. (2), the most critical or relevant pollutant (or groups of pollutant) shall be identified and the pollution load in the space shall be estimated. When this method is used it is required that CO_2 representing the pollutant emission from people (bio effluents) shall be used as one of the gases. Values depending on the category of indoor

Table 5. Non-adapted persons. Examples of recommended ventilation rates for non-residential buildings with default occupant density for three categories of pollution from the building.

Type of building or space	Category	Floor area m^2 per person	q_p minimum ventilation rate		q_B	q_{tot}		q_B	q_{tot}		q_B	q_{tot}	
			l/s per m^2	l/s per person	l/s per m^2	l/s per m^2	l/s per person	l/s per m^2	l/s per m^2	l/s per person	l/s per m^2	l/s per m^2	l/s per person
			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
Auditorium	I	0,75	13,3	10	0,5	13,8	10	1	14,3	10,8	2	15,3	12
	II	0,75	9,3	7	0,35	9,7	7	0,7	10,0	7,5	1,4	10,7	8
	III	0,75	5,3	4	0,2	5,5	4	0,4	5,7	4,3	0,8	6,1	5
	IV	0,75	3,3	2,5	0,15	(3,5) 4.7	(3) 4	0,3	(3,6) 5,3	(2,7) 4	0,6	(3,9) 4,7	(3) 4

Table 6. Adapted persons. Examples of recommended ventilation rates for non-residential buildings with default occupant density for three categories of pollution from building itself.

Type of building or space	Category	Floor area m^2 per person	q_p Adapted q_p according to table B1		q_B	q_{tot}		q_B	q_{tot}		q_B	q_{tot}	
			l/s per m^2	l/s per person	l/s per m^2	l/s per m^2	l/s per person	l/s per m^2	l/s per m^2	l/s per person	l/s per m^2	l/s per m^2	l/s per person
			for occupancy		for very low-polluted building			for low-polluted building			for non-low polluted building		
Conference room	I	2	1,75	3,5	0,5	2,25	4,5	1	2,75	5,5	2	3,75	7,5
	II	2	1,25	2,5	0,35	1,60	(3,2)4	0,7	1,95	(3,9)4	1,4	2,65	5,3
	III	2	0,75	1,5	0,3	1,05	(2,1)4	0,4	1,15	(2,3)4	0,8	1,55	(3,1)4
	IV	2	0,50	1	0,25	0,75	(1,5)4	0,3	0,80	(1,6)4	0,6	1,10	(2,2)4
Auditorium	I	0,75	4,67	3,5	0,5	5,17	(3,9)4	1	5,67	4,3	2	6,67	5,0
	II	0,75	3,33	2,5	0,35	3,68	(2,8)4	0,7	4,03	(3,0)4	1,4	4,73	(3,6)4
	III	0,75	2,00	1,5	0,3	2,30	(1,7)4	0,4	2,40	(1,8)4	0,8	2,80	(2,1)4
	IV	0,75	1,33	1	0,25	1,58	(1,2)4	0,3	1,63	(1,2)4	0,6	1,93	(1,5)4

air are defined for CO_2 in Annex B2 of the standard. Threshold values, based on WHO, for other sources are listed in Annex B6. Emission rates and outdoor concentrations for the gases considered shall be defined based on material testing or certification (see Annex B3 of the standard) and local ambient air quality values.

Method based on pre-defined ventilation air flow rates

This is a method to determine certain pre-defined minimum ventilation air flow rate estimated to meet requirement for both perceived air quality and health in the occupied zone.

The pre-defined ventilation air flow rates shall be expressed by one or more of the following parameters:

- total design ventilation for people and building components (q_{tot});
- design ventilation per unit floor area (q_{m^2}); design ventilation per person (q_p);
- design air change rates (ach); design opening areas (A_{tot}).

Default values are presented in Annex B2 of the standard.

Design ventilation rates in residential buildings

Pre-defined ventilation air flow rates can be given on national level based on one or more of the following criteria: total air change rate for the dwelling, supply air flows for specific rooms, exhaust air flows from specific rooms. In Annex B2 of the standard the default values for the three criteria is shown (see **Table 7**). It is assumed that air is supplied in living rooms and extracted from wet rooms. Both the total air flow rate for the entire dwelling and the exhaust air flow rate from wet rooms shall be calculated. The higher of the two shall be used. In the technical report several examples on default ventilation rates in residential buildings are presented.

The standard is also describing concepts for natural ventilated building, where the criteria based on CO_2 could be used. In annex B2 a methodology for defining default design opening areas for natural ventilation systems in dwelling is presented (see **Table 8**). The opening areas must be provided as supply/extract grilles, stack ducts, window grilles, or similar system.

Table 7. Default criteria based on pre-defined ventilation air flow rates: Total ventilation (1), Supply air flow (2) and (3) supplemented by exhaust air flow.

Category	Total ventilation including air infiltration		Supply air flow per. person	Supply air flow based on perceived IAQ for adapted persons		Supply air flow for bedrooms	Exhaust air flow Peak or boost flow for high demand l/s		
	(1)		(2)	(3)		(4)			
	l/s per m²	ach	l/s per person	q_p l/s per person	q_B l/s per m²	l/s per person	Kitchen (3a)	Bath-rooms (3b)	Toilets (3c)
I	0,49	0,7	10	3,5	0,25	10	28	20	14
II	0,42	0,6	7	2,5	0,15	8	20	15	10
III	0,35	0,5	4	1,5	0,1	4	14	10	7
IV*	0,23	0,4				2,5*	10	6	4

Column 3 and 4: The ventilation air flow rates must be available when the rooms are occupied. The design can take into account that not all bedrooms are occupied at the same time, e.g. during daytime. The number of persons in bedroom depends on the size according to design criteria and building regulations.

* Category IV is intended for the evaluation of IAQ in existing buildings where the space for installations are limited.

Supply air flow for method 3 is based on eq (1).

Table 8. Default design opening areas for dwellings. Values for bedrooms and living rooms may be given per m² floor area or as fixed values per room.

	Extract Kitchen, bathrooms and toilets (cm²)	**Supply** Bedrooms and living rooms (cm²)
Default design opening area	100 per room	60 per room

Filtration and air cleaning

The standard is also setting up some requirements regarding the use of filtration and air cleaning. The influence of position of outdoor air intakes, filtration and air cleaning shall be considered according to prEN 16798-3 (revised EN13779) and the draft technical report TR 16798-2. If filtration and air cleaning is used the following points shall be considered:

- Reducing the amount of airborne pollutants (pollens, molds, spores, particles, dust) from the outdoor air intake by circulating the air through a filter.
- Circulating secondary air through a filter or other air cleaning technology to reduce the amount of pollutants in the air
- Reduce the concentration of odours and gaseous contaminants by circulating the secondary air or recirculating the return air (gas phase air cleaning)

Design guidelines on air cleaning and filtration are given in prEN16798-3 and ISO DIS 16814. How to partially substitute outside air by air cleaning is described in draft TR16798-2.

Lighting

To enable people to perform visual tasks efficiently and accurately, appropriate lighting shall be provided. The degree of visibility and comfort is wide ranging governed by activity type and duration of required lighting criteria for work places as specified in EN12464-1 and for sports lighting in EN 12193. For some visual tasks in buildings and spaces the required lighting default criteria are presented in Annex B4 to the standard. The design illuminance levels shall be obtained by means of daylight, electric light or a combination of both. For reasons of comfort and energy in most cases the use of daylight is preferred. This depends on factors like standard occupancy hours, autonomy (portion of occupancy time during which there is enough daylight), location of the building (latitude), amount of daylight hours during summer and winter, etcetera.

A new thing is the inclusion of a table with default values for daylighting as shown in **Table 9**.

Noise

Guidance for evaluation of noise at the design stage is found in EN 12354-part 5. The noise from building service systems may disturb the occupants and prevent the intended use of the space or building. The noise in a space shall be evaluated using A-weighted equivalent sound pressure level, normalized with respect to reverberation time to take into account the sound absorption of the room. Default values for three categories are then listed in the informative annex to the standard.

Occupant schedules for energy calculations

For energy calculations the result will depend very much on how the occupant schedules will be assumed. In this way it may be very difficult to compare same type of building if different occupant schedules have been used. Therefore the standard prEN16798-1 list several recommended occupant schedules for different type of spaces like residential, offices, schools, restaurant, meeting room, department store, etc. The schedules include criteria for the indoor environment based on the default values, time and level of occupancy and internal loads from other equipment. The criteria used for room temperatures, ventilation, and humidity are based on Category II and very low-polluted building. The internal loads from appliances are based on recent values from a study by REHVA.

Table 9. Daylight availability classification as a function of the daylight factor DCa,j of the raw building envelop opening and DSNA EN15193.

Vertical Facades Daylight factor DCa,j	Roof lights Daylight factor DSNA	Classification of daylight availability
DCa,j ≥ 6%	7% < DSNAa	Strong
6% > DCa,j ≥ 4%	7% > DSNA ≥ 4%	Medium
4% > DCa,j ≥ 2%	4% > DSNA ≥ 2%	Low
DCa,j < 2%	2% > DSNA ≥ 0%	None

a Values of DSNA > 10% should be avoided due to danger of overheating

Additional sections in the technical report

The following sections from the existing standard have all been moved to the technical report with only a few changes.

- Evaluation of the indoor environment and long term indicators
- Inspections and measurement of the indoor environment in existing buildings
- Classification and certification of the indoor environment.

Conclusions

With this revision a more concise standard will be available together with guidance in a technical report.

All criteria listed given as categories in an informative annex are default values. Individual countries may select other values or one category following the concept of the way the default values are expressed.

The inclusion of default occupant schedules will make the calculated energy performance more comparative between buildings. ■

References

[1] CEN/TC156/WG19/N84: prEN16798-1 Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.

[2] CEN/TC156/WG19/N89: draft prCEN/TR 16798-2 WD :Guideline for using indoor environmental input parameters for the design and assessment of energy performance of buildings.

[3] prEN16798-3: Energy performance of buildings - Part 3: Ventilation for non-residential buildings - Performance requirements for ventilation and room-conditioning systems; see also article Claus Händel.