International Centre for Indoor Environment and Energy

Residential Ventilation in the revised EN 15251 (prEN16789-1 and DTR16789-2)

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Existing Standards

- ISO EN 7730-2005
  - Ergonomics of the thermal environment – Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort effects.
- ASHRAE 55-2013
  - Thermal environment conditions for human occupancy
- ASHRAE 62.1 and 62.2 -2013
  - Ventilation and indoor air quality
- EN15251
  - Indoor environmental input parameters for design and assessment of energy performance of buildings- addressing indoor air quality, thermal environment, lighting and acoustic
- EN 13779
  - Ventilation for non-residential buildings - performance requirements for ventilation and room-conditioning systems

Internationale Standarder Indoor Environmental Quality

- prEN16798-1 (EN15251) and ISO CD 17772:
  - Indoor environmental input parameters for the design and assessment of energy performance of buildings.
- TR16798-2 and ISO NWI TR 17772:
  - Guideline for using indoor environmental input parameters for the design and assessment of energy performance of buildings.

Categories

Cate-gory	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

Thermal Environment

Type of building/ space	Category	Operative temperature ^{o}C	
		Minimum for heating (winter season), ~ 1,0 clo	Maximum for cooling (summer season) ~ 0,5 clo
Residential buildings, living spaces (bed room's, living rooms , kitchens etc.) Sedentary activity ~1,2 met	I	21,0	25,5
	II	20,0	26,0
	III	18,0	27,0
	IV	16,0	28,0
Residential buildings, other spaces (utility rooms, storages etc.) Standing-walking activity ~1,5 met	I	18,0	
	II	16,0	
	III	14,0	
Note: A 50% relative humidity level and low air velocity level (< 0.1 m/s) is assumed			

Deviations corresponding to a certain % of occupied hours

- In Danish Building Code
  - < 100 hours above 27 C^o
  - < 25 hours above 28 C^o

x% / y% of period	Weekly Hours 20% 50%	Monthly Hours 12% 25%	Yearly Hours 3% 6%
Working time	8 20	21 44	63 126
Total hours	40	175	2100
Total time Total hours	33 58 166	86 180 720	259 518 8640

CRITERIA FOR INDOOR AIR QUALITY ~VENTILATION RATES

- COMFORT (Perceived Air Quality)
- HEALTH
- PRODUCTIVITY
- ENERGY

Indoor Air Quality

- 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
    - 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
  - Method based on pre-defined ventilation air flow rates

Design Ventilation Air Flow Rates

- The design ventilation air flow rates shall be specified in the design documents, using one of the three methods described in this standard in 6.2.2.1.
- The design ventilation air flow rates shall be used for designing mechanical, natural and hybrid ventilation systems.
- Design ventilation air flow rates shall be specified as an air change per hour for each room, and/or outside air supply and/or required exhaust rates (bathroom, toilets, and kitchens) or given as an overall required air-change rate.

HEALTH CRITERIA FOR VENTILATION

Minimum 4 l/s/person

Specific Pollutans

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.

Design CO_2 concentrations in occupied living rooms and bedrooms

Category	**Design ΔCO_2 concentration for living rooms (ppm above outdoors)**	**Design ΔCO_2 concentration for bedrooms (ppm above outdoors)**
I	550	380
II	800	550
III	1350	**950**
IV	1350	950

NOTES

The above values in Table B2.1.4-4 correspond to the equilibrium concentration when the air flow rate is 4, 7, 10 l/s per person for cat. I, II, III respectively and the CO_2 emission is 20 l /h per person and 13.6 l/h per person for living rooms and bedrooms respectively.

For a 10 m² room (room height 2,5 m, 25 m^3) 4; 7 and 10 l/s per person correspond, with two persons in the room, to an air change rate of 1,2; 2,0 and 2,9 ACH

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

Occupants in Dwellings

- Concerning the scenarios, it's easy to realize that occupation is completely different from non-residential buildings, in fact:
  - occupancy of a dwelling can be strongly variable during the different moments of the day;
  - activities can be much different from one another: sleeping, cooking, having a shower, cleaning, watching tv, etc.
- in residential buildings, the concept of "adapted" people has a great importance: in fact a dwelling is, for the largest part of the time, a private space where the adaptation is practically general, differently e.g. from shops, restaurants and similar, where the first impact on incoming people is essential.
- In residential buildings, ventilation systems should take into account flexibility of use of different rooms: typically e.g. bedrooms are scarcely occupied during daytime and occupied during night time, contrary to living rooms (Demand Control Ventilation)

Ventilation air flow rates for dwellings

- 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.
- This Annex gives in Table B2.1.4-1 the default values for the three criteria. 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
- The values in Table B2.1.4-1 assume that supply air is outdoor air, not air transferred from other rooms. These values may be converted to l/(s m^2) of floor area at national level depending on the average density of occupation of dwellings.

Three methods for ventilation based on pre-defined ventilation air flow rates: Total ventilation (1), Supply air flow (2) and (3) and supplemented by exhaust air flow

Category	Total ventilation including air infiltration (1)		Supply air flow per. person (2)	Supply air flow based on perceived IAQ for adapted persons (3)		Supply air flow for bedrooms (4)		Exhaust air flow, l/s peak or boost flow for high demand		
	l/s,m^2	ach	l/s*per	q_p l/s*per	q_B l/s,m^2	l/s per person		Kit-chen (3a)	Bath-rooms (3b)	Toilets (3c)
I										
II										
III										
IV*										

NOTES

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

Table B2.1.4-1 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 (1)		Supply air flow per. person (2)	Supply air flow based on perceived IAQ for adapted persons (3)		Supply air flow for bedrooms (4)	Exhaust air flow peak or boost flow for high demand l/s		
	l/s,m^2	ach	l/s*per	q_p l/s*per	q_B l/s,m^2	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

NOTES

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

RESIDENTIAL

Category	Supply air flow, l/s				Exhaust air flow, l/s (*)		
	Air change rate (1)	Ventilation per person (2)	Binominal (3)				
	ach (l/s/m^2)	l/s/ person	l/s/person (3a)	l/s/m^2 (3b)	Kitchen	Bathrooms	Toilets
I	0,7 (0,49)	10	3,5	0,25	28	20	14
II	0,6 (0,42)	7	2,5	0,15	20	15	10
III	0,5 (0,35)	4	1,5	0,1	14	10	7
IV	0,4 (0,23)				10	6	4

Notes:

- The values of column (1) refer to internal height of 2,5 m; for different height the coefficient shall be adjusted proportionally, as shown in Table B2.6
- The values of column (1) include the contribution of infiltration
- The ventilation system shall be in any case designed to supply fresh air in the bedrooms when occupied

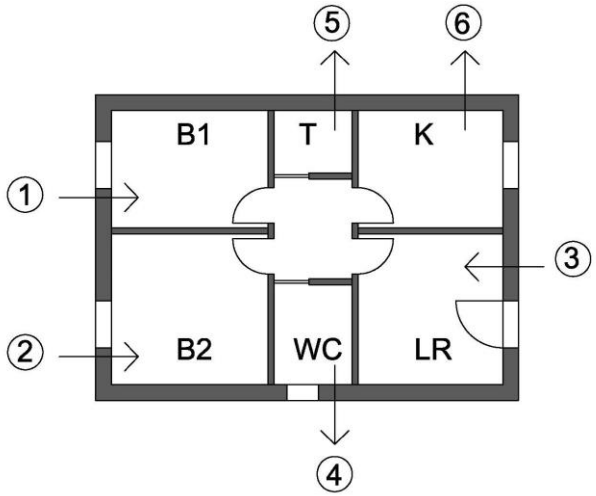
Supply Air Flow

Supply air flow for method 3 is based on eq (1) from section 6.2.2.2

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

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)

Example

Example 1 – Two bedrooms dwelling			
Room	Surface (m^2)	Volume (m^3) internal height 2,7m	
B1	12	32,4	
B2	16	43,2	
T	3,2	8,64	
WC	5,4	14,58	
CORRIDOR	5,4	14,58	
K	12	32,4	
LR	16	43,2	
TOTAL	**70**	**189**	Key: 1,2,3: supply rooms; 4,5,6: exhaust rooms.

Calculation based on air change rate, per person, binomial

Categories	ACH (ref. to the internal height of 2,7m)	total air flow in m^3/h	Correspondent l/s per person (3 persons)	Correspondent l/s per person (4 persons)
I	0,65	122,85	11,38	8,53
II	0,56	105,84	9,80	7,35
III	0,47	88,83	8,22	6,16
IV	0,40	75,6	7	5,25

Categories	l/s per 3 - 4 persons	total flow rates in m^3/h		correspondent values in ach	
		3 persons	4 persons	3 persons	4 persons
I	30 - 40	108	144	0,57	0,76
II	21 - 28	75,6	100,8	0,40	0,53
III	12 - 16	43,2	57,6	0,23	0,30

Cat	Correspondent values in l/s per person		total flow rates in m^3/h		correspondent values in ach	
	3 persons	4 persons	3 persons	4 persons	3 persons	4 persons
I	9,3	7,85	100,8	113,4	0,53	0,60
II	6	5,12	64,8	73,8	0,34	0,39
III	3,83 (4)	3,25 (4)	41,4	46,8	0,22	0,25

Access to operable windows

- The building shall provide access to operable windows or operable elements in the facade to allow the building occupants to make airings and to provide contact to the outside.
- This applies to bedrooms and living rooms in dwellings and other buildings with rooms intended for sleep, e.g. elderly homes.
- It also applies in schools and child care facilities

Natural Ventilation in Dwellings

- Table B2.1.4-3 gives a methodology for defining default design opening areas for natural ventilation systems in dwelling.
- The opening areas must be provided as supply/extract grilles, stack ducts, window grilles, or similar system.
- Outside time of Occupation:
  - The total air flow rate needed to deal with building materials emissions is between 0,1 and 0,15 l/(s*m^2) of floor area (Table B2.1.4-1).

Default design opening areas for dwellings. Values for bedrooms and living rooms may be given per m^2 floor area or as fixed values per room

	Extract Kitchen, bath rooms and toilets (cm^2)	Supply Bedrooms and living rooms (cm^2)
Default design opening area	100 per room	60 per room

Occupant Schedules

Residential, Detached house

Parameters and setpoints

	Parameter	Value	Unit
Operation time	Hour at day, START	0	hour
	Hour at day, END	24	hour
	Breaks, inside range	0	hours
	days/week	7	days
	hours/day	24	hours
	hours/year	8760	hours
Internal gains	Occupants	42.5	m2/pers
	Occupants (Total)	3.3	W/m^2
	Occupants (Dry)	2	W/m^2
	Appliances	2.4	W/m^2
	Lighting		
	Moisture production	1.41	g/(m2, h)
	CO_2 production	0.44	l/(m2, h)
Setpoints	Min T,op in unoccupied hours	16	°C
	Max T,op in unoccupied hours	32	°C
	Min T,op	20	°C
	Max T,op	26	°C
	Ventilation rate (min.)	0.5	l/(s m^2)
	Ventilation rate for CO2 emission	0.16	l/(s m^2)
	Max CO_2 concentration (above outdoor)	500	ppm
	Min. relative humidity	25	%
	Max. relative humidity	60	%
	Lighting, illuminance in working areas	0	lux
Other	Domestic hot water use	100	l/(m2 year)

* u.r. : Usage rate, summed load factors/usage time

Usage schedule

	Energy calculation					
	Weekdays			Weekends		
h	Occupants	Appliances	Lighting	Occupants	Appliances	Lighting
1	1	0.5	0	0	0	0
2	1	0.5	0	0	0	0
3	1	0.5	0	0	0	0
4	1	0.5	0	0	0	0
5	1	0.5	0	0	0	0
6	1	0.5	0	0	0	0
7	0.5	0.5	0.15	0	0	0
8	0.5	0.7	0.15	0	0	0
9	0.5	0.7	0.15	0	0	0
10	0.1	0.5	0.15	0	0	0
11	0.1	0.5	0.05	0	0	0
12	0.1	0.6	0.05	0	0	0
13	0.1	0.6	0.05	0	0	0
14	0.2	0.6	0.05	0	0	0
15	0.2	0.6	0.05	0	0	0
16	0.2	0.5	0.05	0	0	0
17	0.5	0.5	0.2	0	0	0
18	0.5	0.7	0.2	0	0	0
19	0.5	0.7	0.2	0	0	0
20	0.8	0.8	0.2	0	0	0
21	0.8	0.8	0.2	0	0	0
22	0.8	0.8	0.2	0	0	0
23	1	0.6	0.15	0	0	0
24	1	0.6	0.15	0	0	0
*u.r.	0.60	0.60	0.10	0.00	0.00	0.00

Occupant Schedules

Residential, apartment, retired

Parameters and setpoints

	Parameter	Value	Unit
Operation time	Hour at day, START	0	hour
	Hour at day, END	24	hour
	Breaks, inside range	0	hours
	days/week	7	days
	hours/day	24	hours
	hours/year	8760	hours
Internal gains	Occupants	28.3	m2/pers
	Occupants (Total)	5	W/m^2
	Occupants (Dry)	3	W/m^2
	Appliances	3	W/m^2
	Lighting		
	Moisture production	2.12	g/(m2, h)
	CO_2 production	0.66	l/(m2, h)
Setpoints	Min T,op in unoccupied hours	16	°C
	Max T,op in unoccupied hours	32	°C
	Min T,op	20	°C
	Max T,op	26	°C
	Ventilation rate (min.)	0.5	$l/(s\ m^2)$
	Ventilation rate for CO2 emission	0.28	$l/(s\ m^2)$
	Max CO_2 concentration (above outdoor)	500	ppm
	Min. relative humidity	25	%
	Max. relative humidity	60	%
	Lighting, illuminance in working areas	0	lux
Other	Domestic hot water use	100	l/(m2 year)

* u.r. : Usage rate, summed load factors/usage time

Usage schedule

	Energy calculation					
	Weekdays			Weekends		
h	Occupants	Appliances	Lighting	Occupants	Appliances	Lighting
1	1	0.5	0	0	0	0
2	1	0.5	0	0	0	0
3	1	0.5	0	0	0	0
4	1	0.5	0	0	0	0
5	1	0.5	0	0	0	0
6	1	0.5	0	0	0	0
7	1	0.5	0.15	0	0	0
8	1	0.7	0.15	0	0	0
9	1	0.7	0.15	0	0	0
10	1	0.5	0.15	0	0	0
11	1	0.5	0.05	0	0	0
12	1	0.6	0.05	0	0	0
13	1	0.6	0.05	0	0	0
14	1	0.6	0.05	0	0	0
15	1	0.6	0.05	0	0	0
16	1	0.5	0.05	0	0	0
17	1	0.5	0.2	0	0	0
18	1	0.7	0.2	0	0	0
19	1	0.7	0.2	0	0	0
20	1	0.8	0.2	0	0	0
21	1	0.8	0.2	0	0	0
22	1	0.8	0.2	0	0	0
23	1	0.6	0.15	0	0	0
24	1	0.6	0.15	0	0	0
*u.r.	1.00	0.60	0.10	0.00	0.00	0.00

Schedule

- EN 15251rev
  - prEN enquiry May-September 2015
  - Final standard February 2016
- ISO 17772
  - DIS enquery June-October 2015
  - Final standard March 2016

Thank You