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Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics

Critères pour l'environnement intérieur et évaluation des performances énergétiques des bâtiments couvrant la qualité d'air intérieur, la thermique, l'éclairage et l'acoustique

Eingangsparameter für das Raumklima zur Auslegung und Bewertung der Energieeffizienz von Gebäuden - Raumluftqualität, Temperatur, Licht und Akustik

This European Standard was approved by CEN on 26 March 2007.

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Foreword

This document (EN 15251:2007) has been prepared by Technical Committee CEN/TC 156 “Ventilation for buildings”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2007, and conflicting national standards shall be withdrawn at the latest by November 2007.

This standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association (Mandate M/343), and supports essential requirements of EU Directive 2002/91/EC on the energy performance of buildings (EPBD). It forms part of a series of standards aimed at European harmonisation of the methodology for the calculation of the energy performance of buildings. An overview of the whole set of standards is given in CEN/TR 15615, Explanation of the general relationship between various CEN standards and the Energy Performance of Buildings Directive (EPBD) ("Umbrella document").

Attention is drawn to the need for observance of relevant EU Directives transposed into national legal requirements. Existing national regulations with or without reference to national standards, may restrict for the time being the implementation of the European Standards mentioned in this report.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

Energy consumption of buildings depends significantly on the criteria used for the indoor environment (temperature, ventilation and lighting) and building (including systems) design and operation. Indoor environment also affects health, productivity and comfort of the occupants. Recent studies have shown that costs of poor indoor environment for the employer, the building owner and for society, as a whole are often considerable higher than the cost of the energy used in the same building. It has also been shown that good indoor environmental quality can improve overall work and learning performance and reduce absenteeism. In addition uncomfortable occupants are likely to take actions to make themselves comfortable which may have energy implications. An energy declaration without a declaration related to the indoor environment makes no sense. There is therefore a need for specifying criteria for the indoor environment for design, energy calculations, performance and operation of buildings

There exist national and international standards, and technical reports, which specify criteria for thermal comfort and indoor air quality (EN ISO 7730, CR 1752). These documents do specify different types and categories of criteria, which may have a significant influence on the energy demand. For the thermal environment criteria for the heating season (cold/winter) and cooling season (warm/summer) are listed. These criteria are, however, mainly for dimensioning of building, heating, cooling and ventilation systems. They may not be used directly for energy calculations and year-round evaluation of the indoor thermal environment. New results have shown that occupant expectations in natural ventilated buildings may differ from conditioned buildings. These issues are not dealt with in detail in the above mentioned documents.

The present standard specifies how design criteria can be established and used for dimensioning of systems. It defines how to establish and define the main parameters to be used as input for building energy calculation and long term evaluation of the indoor environment. Finally this standard will identify parameters to be used for monitoring and displaying of the indoor environment as recommended in the Energy Performance of Buildings Directive.

Different categories of criteria may be used depending on type of building, type of occupants, type of climate and national differences. The standard specifies several different categories of indoor environment which could be selected for the space to be conditioned. These different categories may also be used to give an overall, yearly evaluation of the indoor environment by evaluating the percentage of time in each category. The designer may also select other categories using the principles from this standard.

1 Scope

- This European Standard specifies the indoor environmental parameters which have an impact on the energy performance of buildings.
- The standard specifies how to establish indoor environmental input parameters for building system design and energy performance calculations.
- The standard specifies methods for long term evaluation of the indoor environment obtained as a result of calculations or measurements.
- The standard specifies criteria for measurements which can be used if required to measure compliance by inspection.
- The standard identifies parameters to be used by monitoring and displaying the indoor environment in existing buildings.
- This standard is applicable mainly in non-industrial buildings where the criteria for indoor environment are set by human occupancy and where the production or process does not have a major impact on indoor environment. The standard is thus applicable to the following building types: single family houses, apartment buildings, offices, educational buildings, hospitals, hotels and restaurants, sports facilities, wholesale and retail trade service buildings.
- The standard specifies how different categories of criteria for the indoor environment can be used. But does not require certain criteria to be used. This is up to national regulations or individual project specifications.
- The recommended criteria in this standard can also be used in national calculation methods, which may be different to the methods referred to here.
- The standard does not prescribe design methods, but give input parameters to the design of buildings, heating, cooling, ventilation and lighting systems.
- The standard does not include criteria for local discomfort factors like draught, radiant temperature asymmetry, vertical air temperature differences and floor surface temperatures.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12464-1	2002	*Light and lighting — Lighting of work places — Part 1: Indoor work places*
EN 12599		*Ventilation for buildings — Test procedures and measuring methods for handing over installed ventilation and air conditioning systems*
EN 12792	2003	*Ventilation for buildings — Symbols, terminology and graphical symbols*
EN 12831		*Heating systems in buildings — Method for calculation of the design heat load*

EN 15193		*Energy performance of buildings — Energy requirements for lighting*
EN 15241		*Ventilation for buildings — Calculation methods for energy losses due to ventilation and infiltration in commercial buildings*
EN 15242		*Ventilation for buildings — Calculation methods for the determination of air flow rates in buildings including infiltration*
prEN 15255		*Thermal performance of buildings — Sensible room cooling load calculation — General criteria and validation procedures*
prEN 15265		*Thermal performance of buildings — Calculation of energy needs for space heating and cooling using dynamic methods — General criteria and validation procedures*
EN ISO 7726		*Ergonomics of the thermal environment — Instruments for measuring physical quantities (ISO 7726:1998)*
EN ISO 7730		*Ergonomics of the thermal environment — Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria (ISO 7730:2005)*
EN ISO 8996		*Ergonomics of the thermal environment — Determination of metabolic rate (ISO 8996:2004)*
EN ISO 9920		*Ergonomics of the thermal environment — Estimation of the thermal insulation and evaporative resistance of a clothing ensemble (ISO 9920:1995)*
EN ISO 13731	2001	*Ergonomics of the thermal environment — Vocabulary and symbols (ISO 13731:2001)*
EN ISO 13790		*Thermal performance of buildings — Calculation of energy use for space heating (ISO 13790:2004)*
ISO/TS 14415		*Ergonomics of the thermal environment — Application of International Standards to people with special requirements*
CIE 69		*Methods of characterizing illuminance meters and luminance meters; performance, characteristics and specifications*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12792:2003, EN ISO 13731:2001, EN 12464-1:2002 and the following apply.

3.1
adaptation
physiological, psychological or behavioural adjustment of building occupants to the interior thermal environment in order to avoid discomfort

NOTE In naturally ventilated buildings these are often in response to changes in indoor environment induced by outside weather conditions.

3.2
active cooling
see mechanical cooling

3.3
buildings, very low-polluting
buildings where an extraordinary effort has been done to select low-emitting materials and activities with emission of pollutants are prohibited and no previous emitting sources (like tobacco smoke) was present

NOTE Criteria are listed in Annex G.

3.4
buildings, low-polluting
buildings where an effort has been done to select low-emitting materials and activities with emission of pollutants are limited or prohibited

NOTE Criteria are listed in Annex G

3.5
buildings, not low-polluting
old or new buildings where no effort has been done to select low-emitting materials and activities with emission of pollutants not prohibited

NOTE Previous emissions (like tobacco smoke) may have taken place.

3.6
buildings without mechanical cooling
buildings that do not have any mechanical cooling and rely on other techniques to reduce high indoor temperature during the warm season like moderately-sized windows, adequate sun shielding, use of building mass, natural ventilation, night time ventilation etc. for preventing overheating

3.7
cooling season
part of the year during which (at least parts of the day and part of the building, usually summer) cooling appliances are needed to keep the indoor temperatures at specified levels

NOTE The length of the cooling season differs substantially from country to country and from region to region).

3.8
daylight factor (D)
ratio of the illuminance at a point on a given indoor plane due to the light received directly or indirectly from the sky of assumed or known illuminance distribution, to the illuminance on a horizontal plane due to an unobstructed hemisphere of this sky. The contribution of direct sunlight to both illuminances is excluded

[EN 12665:2002]

NOTE usually expressed as a percentage

3.9
demand controlled ventilation
ventilation system where the ventilation rate is controlled by air quality, moisture, occupancy or some other indicator for the need of ventilation

3.10
external temperature, daily mean
average of the hourly mean external air temperature for one day (24 h)

3.11
external temperature, running mean
exponentially weighted running mean of the daily mean external air temperature Θ_{ed} is such a series, and is calculated from the formula:

$$\Theta_{rm} = (1- \alpha).\{ \Theta_{ed\ -1} + \alpha.\ \Theta_{ed\ -2} + \alpha^2\ \Theta_{ed\ -3}.....\} \qquad (1)$$

This equation can be simplified to

$$\Theta_{rm} = (1- \alpha)\Theta_{ed\ -1} + \alpha.\ \Theta_{rm-1} \qquad (2)$$

Where

Θ_{rm} = Running mean temperature for today

Θ_{rm-1} = Running mean temperature for previous day

Θ_{ed-1} is the daily mean external temperature for the previous day

$\Theta_{ed\ -2}$ is the daily mean external temperature for the day before and so on.

α is a constant between 0 and 1. Recommended to use 0,8

The following approximate equation can be used where records of daily mean external temperature are not available:

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

3.12
heating season
parts of the year during which (at least parts of the day and part of the building, usually winter) heating appliances are needed to keep the indoor temperatures at specified levels

NOTE The length of the heating season differs substantially from country to country and from region to region).

3.13
mechanical cooling
cooling of the indoor environment by mechanical means used to provide cooling of supply air, fan coil units, cooled surfaces, etc.

NOTE The definition is related to people's expectation regarding the internal temperature in warm seasons. Opening of windows during day and night time is not regarded as mechanical cooling. Any mechanical assisted ventilation (fans) is regarded as mechanical cooling.

3.14
optimal operative temperature
operative temperature where a maximum number of the occupants can be expected to feel the indoor temperature acceptable

NOTE For mechanical cooled building it corresponds to PMV = 0.

3.15
occupied hours
occupied hours of the building are those when the majority of the building is in its intended use

3.16
room conditioning system
system able to keep a comfort conditions in a room within a defined range

NOTE Air conditioning as well radiant, surface heating and cooling systems are included.

3.17
ventilation rate
magnitude of outdoor air flow to a room or building either through the ventilation system or infiltration through building envelope

3.18
ventilation system
combination of appliances designed to supply interior spaces with outdoor air and to extract polluted indoor air

NOTE The system can consist of mechanical components (e.g. combination of air handling unit, ducts and terminal units). Ventilation system can also refer to natural ventilation systems making use of temperature differences and wind with facade grills in combination with exhaust (e.g. in corridors, toilets etc.). Both mechanical and natural ventilation can be combined with operable windows. A combination of mechanical and non-mechanical components is possible (hybrid systems).

4 Symbols and abbreviations

Θ_o = indoor operative temperature, °C

Θ_e = external temperature, °C

q_{tot}= total ventilation rate, l/s

q_B= ventilation rate for building materials,l/(sm^2)

q_p= ventilation rate for persons, l/(s,person)

n = number of persons, -

A= floor area, m^2

$L_{p,A}$= A-weighed sound pressure level, dB(A)

$L_{p,eq,A}$=equivalent A-weighed sound pressure level, dB(A)

D = Daylight factor

$\hat{E}_m$ = Maintained (average) illuminance

E = Illuminance (at a point or surface)

R_a = Colour rendering index

5 Interactions with other standards

The present standard both gives input to other standards and is using outputs from other standards. The diagram shows an overview of the interaction with other standards related to the EPBD.

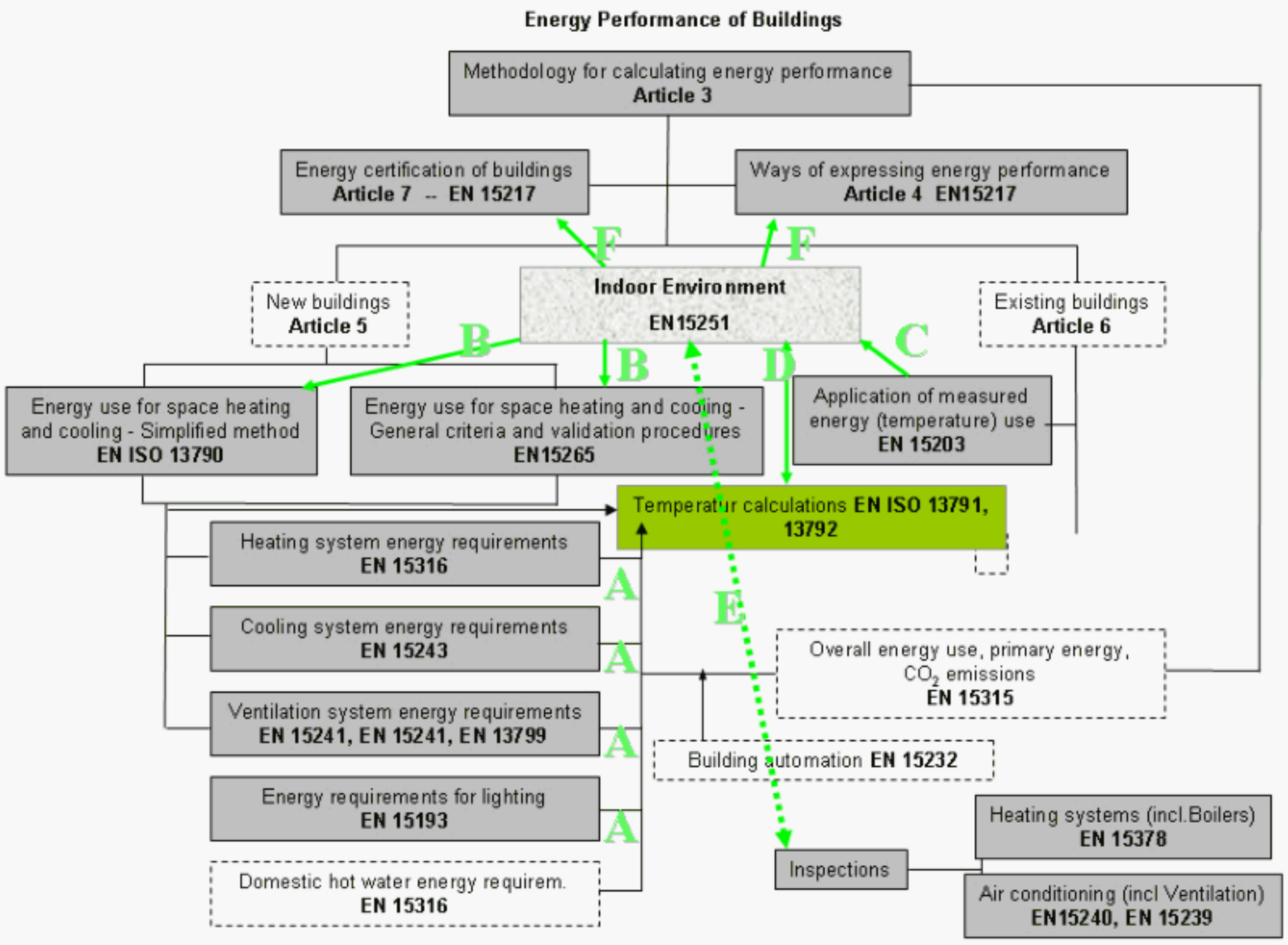


Figure 1 — Diagram showing the interaction with other standards related to the EPBD

The present standard will interact in the following way with other standards

A It will provide indoor environmental criteria for the design of building and HVAC systems. The thermal criteria (design indoor temperature in winter, design indoor temperature in summer) are used as input for heating (EN 12831) and cooling load (prEN 15243) calculations and sizing of the equipment. Ventilation rates are used for sizing ventilation systems (Clause 6), and lighting levels for design of lighting system including the use of day lighting.

The design values for sizing the building services are needed to fulfil the requirements in the article 4 of EPBD referring to possible negative effect of indoor environment and to give advice in respect improvement of the energy efficiency of existing buildings (article 6) as well as of the heating (article 8) and cooling (article 9) of building.

B It will provide values for the indoor environment (temperature, ventilation, lighting) as input to the calculation of the energy demand (building energy demand), when the space is occupied, (EN ISO 13790, prEN 15255, prEN 15265) (Clause 7). It will also provide standardised input values which are needed for energy calculations as required calculations specified in article 3 of EPBD.

C Output from measured environmental parameters in existing buildings (prEN 15203, temperature, indoor air quality, ventilation rates) will enable the evaluation of overall annual performance (Clause 8).

This evaluation is necessary for the display of the climatic factors (indoor environment) in the energy performance certificate (article 6 and 7 of EPBD).

D Output from room temperature calculations (EN ISO 13791, EN ISO 13792) will enable evaluation of the annual performance of buildings (Clause 8). This evaluation is necessary for the display of climatic factors (indoor environment) in the energy performance certificate (article 7 of EPBD) when the evaluation is based on calculations (article 7 of EPBD).

E It will provide methods for measurement of the indoor environment and for treating measured data related to the inspection of HVAC systems (EN 15240, EN 15239, prEN 15378) (Clause 9). This information is necessary to give advice related to the heating loads and system (article 8 of EPBD) and air conditioning load and system (article 9 of EPBD) of a building.

F It will provide a method for categorisation of indoor environment (prEN 15217) (Clause 10). This method is necessary to integrate complex indoor environment information to simple classification for the energy certificate (article 7 of EPBD).

Recommended input values are given for each of the different categories. A short description of the categories is shown in Table 1.

Table 1 — Description of the applicability of the categories used

Category	Explanation
I	High level of expectation and is recommended for spaces occupied by very sensitive and fragile persons with special requirements like handicapped, sick, very young children and elderly persons
II	Normal level of expectation and should be used for new buildings and renovations
III	An acceptable, moderate level of expectation and may be used for existing buildings
IV	Values outside the criteria for the above categories. This category should only be accepted for a limited part of the year

NOTE In other standards like EN 13779 and EN ISO 7730 categories are also used; but may be named different (A, B, C or 1, 2, 3 etc.)

6 Design input criteria for dimensioning of buildings, heating, cooling, mechanical and natural ventilation systems

6.1 General

For design of buildings and dimensioning of room conditioning systems the thermal comfort criteria (minimum room temperature in winter, maximum room temperature in summer) shall be used as input for heating load (EN 12831) and cooling load (prEN 15255) calculations. This will guarantee that a minimum-maximum room temperature can be obtained at design outdoor conditions and design internal loads. Ventilation rates that are used for sizing the equipment shall be specified in design (EN 15241, EN 15242). This clause presents input values for the sizing and dimensioning of the systems as well as for design of buildings without mechanical cooling.

Criteria specified in national building codes for design and dimensioning of systems shall be used. The present standard gives, in informative annexes, recommended input values for use in cases where no national regulation are available. The recommended criteria are given for several categories. Design criteria for the indoor environment shall be documented by the designer. Design criteria for the indoor environment can be displayed along with the energy certificate.

6.2 Thermal environment

6.2.1 Mechanically heated and/or cooled buildings

Design values for the indoor temperature for heating load and cooling load calculations shall be specified at national level.

For establishing design criteria the following procedure is recommended.

Criteria for the thermal environment shall be based on the thermal comfort indices PMV-PPD (predicted mean vote - predicted percentage of dissatisfied) with assumed typical levels of activity and thermal insulation for clothing (winter and summer) as described in detail in EN ISO 7730. Based on the selected criteria (comfort category) a corresponding temperature interval is established. The values for dimensioning of cooling systems are the upper values of the comfort range and values for dimensioning of the heating system are the lower comfort values of the range. Some examples of recommended design indoor operative temperatures, derived according to this principle, for heating and cooling are presented in Table A.2.

The design values for sizing the building services are needed to fulfil the requirements in the article 4 of EPBD referring to possible negative effects of the indoor environment and to give advice about improvement of the energy efficiency of existing buildings (article 6) as well as of the heating (article 8) and cooling (article 9) of building. The design criteria in this clause are both for design of buildings (window, sun shielding, building mass, etc) and HVAC systems.

Instead of using temperature as the design criterion the PMV-PPD index can be used directly. In this way the effect of increased air velocity will be taken into account.

Selection of the category is building specific, and the needs of special occupant groups such as elderly people (low metabolic rate and impaired control of body temperature) shall be considered (ISO/TS 14415). For this group of people category I is recommended.

For buildings and spaces were the mechanical cooling capacity is not adequate to meet the required temperature categories the design documents shall state, using one of the methods in Annex F, how often the conditions are outside the required range.

6.2.2 Buildings without mechanical cooling

For the dimensioning of the heating system the same criteria as for mechanically ventilated, cooled and heated buildings shall be used (6.2.1).

The criteria for the thermal environment in buildings without mechanical cooling may be specified using the same method as in 6.2.1 or differently from those with mechanical cooling during the warm season due to the different expectations of the building occupants and their adaptation to warmer conditions. The level of adaptation and expectation is strongly related to outdoor climatic conditions.

In summer most naturally ventilated buildings are free-running so there is no mechanical cooling system to dimension and the criteria for the categories are based on indoor temperature. Summer temperatures are mainly used to design for the provision of passive thermal controls (e.g. solar shading, thermal capacity of building, design, orientation and opening of windows, etc) to avoid over heating of the building.

Recommended criteria for the indoor temperature are given in A.2 based on a running mean outside temperature.

For buildings and spaces were the building design and natural ventilation is not adequate to meet the required temperature categories the design documents shall state, using one of the methods in Annex F, how often the conditions are outside the required range.

6.2.3 Local thermal discomfort

Criteria for local thermal discomfort such as draught, radiant temperature asymmetry, vertical air temperature differences and floor surface temperatures shall also be taken into account for the design of building and HVAC systems. These criteria are not included in this standard; but can be found in EN ISO 7730 or national codes.

6.3 Indoor air quality and ventilation rates

6.3.1 Non-residential buildings

For design of ventilation systems and calculation of heating and cooling loads the required ventilation rate shall be specified in the design documents based on national requirements or using one of the recommended methods in this standard (see B.1).

It is possible to design for different categories of indoor air quality, which will influence the required ventilation rates. The different categories of air quality can be expressed in different ways (combination of ventilation for people and building components, ventilation per m^2 floor area, ventilation per person or according to required CO_2 level) as shown in Annex B. The design documents shall document, which method has been used.

The ventilation rates for air quality are independent of season. They depend on occupancy, activities indoors (i.e. smoking, cooking, cleaning, washing…), processes (like copiers in offices, chemicals in school buildings, etc…) and emissions from building materials as well as furniture.

In the design and operation the main sources of pollutants should be identified and eliminated or decreased by any feasible means. The remaining pollution is then dealt by local exhausts, and ventilation.

6.3.2 Residential buildings

Indoor air quality in residential buildings depends of many parameters and sources like number of persons (time of occupation), emissions from activities (smoking, humidity, intensive cooking), emissions from furnishing, flooring materials and cleaning products, hobbies etc. Humidity is of particular concern in residential ventilation as most of adverse health effects and building disorder (condensation, moulds,) is related to humidity. Several of these sources cannot be influenced or controlled by the designer.

Required design ventilation 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. Most national regulations and codes give precise indications on detailed airflows per room and shall be followed. The required rates shall be used for designing mechanical-, natural- and exhaust ventilation systems.

This standard gives, in B.2, default values to use in case no national regulation is available.

The default ventilation rates in B.2 are based on average use of a residence. In operation some residences may need more ventilation and some may manage with lower ventilation rates. National regulations as well as international standards help the designer to determine assumptions made on standard residential sources and the correct airflow to achieve.

6.3.3 Filtration and air cleaning

Although filtration is usually dimensioned for maintaining equipment performance, it can also be used to improve indoor air quality with:

- Treatment of outdoor air in very polluted area
- Limiting the entry of pollens from outdoors
- Removal of odours and gaseous contaminants (gas phase air cleaning).

Design guidelines on air cleaning and filtration are given in EN 13779 and ISO/DIS 16814.

6.4 Humidity

The humidification of indoor air is usually not needed. Humidity has only a small effect on thermal sensation and perceived air quality in the rooms of sedentary occupancy, however, long term high humidity indoors will cause microbial growth, and very low humidity, (<15-20%) causes dryness and irritation of eyes and air ways. Requirements for humidity influence the design of dehumidifying (cooling load) and humidifying systems and will influence energy consumption. The criteria depend partly on the requirements for thermal comfort and indoor air quality and partly on the physical requirements of the building (condensation, mould etc.) For special buildings (museums, historical buildings, churches) additional humidity requirements shall be taken into account. Humidification or dehumidification of room air is usually not required but if used excess humidification and dehumidification avoided.

Recommended design values of indoor humidity for occupied spaces for dimensioning of dehumidification and humidification systems are given in B.3.

6.5 Lighting

6.5.1 Non residential buildings

To enable people to perform visual tasks efficiently and accurately, adequate light (without side effects like glare and blinding) shall be provided. The required task illuminance is defined and detailed in EN 12464-1 and for some tasks is presented in Table D.1. For sports lighting EN 12193 can be used.

NOTE 1 Light in residential buildings and emergency lighting is beyond the scope of this document.

The design illuminance levels can be secured by means of daylight, artificial light or a combination of both. For reasons of health, comfort and energy in most cases the use of daylight (maybe with some additional lighting) is preferred over the use of artificial light. Of course this depends on many 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.

To make sure that at least a reasonable amount of occupancy time (daylight) can be used, it is recommended to set demands on the daylight penetration in the spaces meant for human occupancy. EN 15193 provides details of occupancy periods and daylight availability and estimations. When it comes to illuminance a distinction in categories seems less appropriate than e.g. for temperature and fresh air supply.

NOTE 2 Windows which are too small may be a problem (not enough daylight, impaired well being etc). Windows that are unprotected and are too big can also be a problem too in terms of overheating.

6.6 Noise

For design of ventilation the required sound levels shall be specified in the design documents based on national requirements. If this is not the case the recommended values listed in this standard (see Annex E) may be applied if appropriate.

The noise from the HVAC systems of the building may disturb the occupants and prevent the intended use of the space or building. The noise in a space can be evaluated using A-weighted equivalent sound pressure level.

Table E.1 is only based on noise from service equipment and not outside noise. Often national requirements exist for noise from service equipment inside or outside assuming windows are closed.

These criteria apply to the sources from the building as well as the noise level from outdoor service equipment. The criteria should be used to limit the sound pressure level from the mechanical equipment and to set sound insulation requirements for the noise from outdoors and adjacent rooms.

The values can in some countries be exceeded in the case when the occupant can control the operation of the equipment or the windows. For example a room air conditioner may generate a higher sound pressure level if its operation is controlled by the occupant, but even in this case the rise of the sound pressure level over the values in Annex E should be limited to between 5 and 10 dB (A). National requirements may differ.

Ventilation should not rely on opening of windows in the areas with high outdoor noise where it is not possible to reach the target level when airing or if the building is located in an area with a high outdoor noise level compared to the level the designer wishes to achieve in the indoor zone. National regulations often set requirements for ventilation conditions (including airing) and shall be followed..

7 Indoor environment parameters for energy calculation

7.1 General

Standardised input values for the energy calculations are needed for calculations specified in article 3 and in the annex of EPBD. To perform a yearly energy calculation (EN ISO 13790) criteria for the indoor environment shall be specified and documented.

7.2 Thermal environment

7.2.1 General

As the energy calculations may be performed on seasonal, monthly of hourly basis (dynamic simulation) the indoor environment is specified accordingly. Indoor temperature criteria for heating and for cooling shall be specified.

7.2.2 Seasonal calculations

For seasonal and monthly calculations of energy consumption for heating and cooling respectively the same values of indoor temperature as for design (sizing) the heating and cooling systems shall be used (6.2) for each category of indoor environment. Assumptions regarding clothing level (EN ISO 9920) and activity level (EN ISO 8996) shall be listed.

7.2.3 Hourly calculations (dynamic simulation)

In dynamic simulation the energy consumption is calculated on an hourly basis. Recommended values for the acceptable range of the indoor temperature for heating and cooling are presented in A.3. The midpoint of the temperature range should be used as a target value but the indoor

temperature may fluctuate within the range according to the energy saving features or control algorithm. If the cooling power is limited (mixed mode buildings) the excess indoor temperatures shall be estimated using one of the methods in Clause 8. Consideration may be given to allowing the indoor temperature to rise above the recommended values in A.3.

Assumptions regarding clothing level (EN ISO 9920) and activity level (EN ISO 8996) shall be listed.

7.3 Indoor air quality and ventilation

7.3.1 Non-residential buildings

During the hours of operation the ventilation rates for energy calculations shall be the same as specified in Clause 6 for design load calculations and dimensioning of the ventilation system. To guarantee good indoor air quality in the beginning of the occupancy the ventilation shall start before the occupancy or a minimum ventilation rate provided during un-occupied hours. If no national regulations exist the recommendations in B.4 should be used.

In systems with variable air flow control and demand controlled ventilation the ventilation rate may vary between maximum for full occupancy or demand and minimum for non occupied space. In the case of CO_2-controlled ventilation the CO_2-concentration should not exceed the design values. Recommended values for the excess of CO_2 concentration above outdoors CO_2 concentration are listed in Table B.4. The values of pollution generation presented in EN 13779 can be used in design of the demand controlled ventilation.

7.3.2 Residential buildings

7.3.2.1 Mechanical ventilation

In residential buildings the minimum ventilation rate is usually constant as specified in the design (Clause 6, B.2) during occupied hours.

Residential buildings should be ventilated during unoccupied periods with a lower ventilation rate than during the occupied period. This minimum ventilation rate shall be defined based on the pollution load of the spaces. If no national regulation is available the values in B.4 are recommended.

In systems with variable air flow controlled by any criteria representing demand, timer or occupancy detection, the ventilation rate may vary between maximum and minimum depending on the occupancy and pollution load such as moisture generation. If Demand Controlled systems or occupation and usage detection are used, they shall achieve the chosen criteria. Rules and criteria for this relationship of equivalence have to be assumed according to national regulations and at national levels.

As variable systems may have variations in flow over time, equivalence rules (equivalence to a constant air flow) on any IAQ criteria may be chosen at national level to make allowances in this respect.

7.3.2.2 Natural ventilation

Ventilation rates in naturally ventilated buildings are calculated based on building layout, location and weather conditions according to EN 15242. The minimum ventilation rate is specified in the design (Clause 6) is used for energy calculations during occupied hours. As other variable systems, natural ventilation using stack effect may have variations in flow over time, equivalence rules on any IAQ criteria may be chosen at national level to make allowances in this respect.

During unoccupied periods minimum ventilation for the buildings should be provided. If national regulations and codes are not available recommended values in B.4 may be used. National codes

may allow complementary ventilation by airing to achieve this requirement in mild season if acoustic requirements can be met.

7.4 Humidity

The criteria used for equipment design and sizing (6.2.3, B.3) shall be used also in energy calculations. Indoor air shall not be dehumidified to a lower relative humidity than the design value and not humidified into higher relative humidity than the design values besides an upper limit for the absolute humidity is recommended. Unoccupied buildings shall not be humidified (with some exceptions such as museums) but may need to be dehumidified to prevent long term moisture damage.

7.5 Lighting

7.5.1 Non-residential buildings

The required lighting level is independent of season and the same criteria as for dimensioning of lighting systems shall be used (see 6.5 and EN 15193) for energy calculations. The required lighting level can be obtained by natural lighting, artificial lighting or a combination. The choice of light source will have an impact on the building energy demand. It is essential to evaluate also the quality of lighting in the energy calculations in respect of glare which may affect the use of controls and window screens. Recommended criteria for lighting are described in detail in EN 12464-1. Some of the criteria from EN 12464-1 are presented in Table D.1.

7.5.2 Residential buildings

Energy consumption of lighting shall be calculated by using accepted national values in kWh per m^2 per year or similar.

8 Evaluation of the indoor environment and long term indicators

8.1 General

As the loads of any building vary from place to place and from time to time the designed system may not be able to fulfil the design intent in all rooms during all hours. There is a need to evaluate the long term performance of building in respect of indoor environment. This evaluation is necessary for the display of the climatic factors (indoor environment) in the energy performance certificate (article 6 and 7). This clause presents indicators for such evaluation and their use. The evaluation of indoor environment of a building is done by evaluating the indoor environment of typical rooms representing different zones in the building. Evaluation can be based on (1) design (8.2) (2) calculations, (8.3) (3) measurements (8.4) or (4).questionnaires (8.5)

8.2 Design indicators

Evaluation of the category of indoor environment of a building is based on the categories of the following indoor environmental factors:

(1) **thermal criteria for winter:** Specified design values for indoor temperature during heating (6.2.1)

(2) **thermal criteria for summer:** Specified design values for indoor temperatures during cooling (6.2.1 and 6.2.2)

(3) **air quality and ventilation criteria:** design values for ventilation are in 6.3.1 for non residential buildings, and for residential buildings in 6.3.2

(4) **humidity criteria**: design values for humidity are in 6.4

(5) **lighting criteria:** design values for lighting are in 6.5

(6) **acoustic criteria:** design values for noise are given in 6.6

8.3 Calculated indicators of indoor environment

8.3.1 General

Building simulation is a cost effective way to analyse the performance of buildings. The computer programs used shall be validated according to prEN 15265 and prEN 15255. Various indicators of indoor environment can be calculated for different purposes. In the following four methods are presented for the thermal evaluation.

8.3.2 Simple indicator

To evaluate the performance of the whole building representative rooms or spaces have to be simulated. The building meets the criteria of a specific category if the rooms representing 95 % of building volume meet the criteria of the selected category.

8.3.3 Hourly criteria

Performance of the buildings or rooms with different mechanical or electrical systems can be evaluated by calculating the number of actual hours or % of time when the criteria is met or not.

This procedure is described with an example in Annex F.

8.3.4 Degree hours criteria

In respect of the thermal environment the degree hours outside the upper or lower boundary can be used as a performance indicator of building for warm or cold season.

This procedure is described with an example in Annex F.

8.3.5 Overall thermal comfort criteria (weighted PMV criteria)

This procedure is described with an example in Annex F.

8.4 Measured indicators

8.4.1 General

Deviations from the selected criteria shall be allowed. Some national criteria express ‘acceptable deviations’ as an acceptable number of hours outside the criteria based on a yearly evaluation (like 100 to 150 h). This may also be given as weighted hours, where the level of deviation also is taken into account.

If no national criteria for deviations are available the recommended criteria in Annex G can be used. These criteria can be given on a daily, weekly, monthly and yearly basis.

8.4.2 Thermal environment

The measurements shall be taken in representative rooms at different zones, orientations, with different loads during representative operation periods. The evaluation of the category of indoor environment is based on temporal and spatial distribution of the room temperature. Measurements points and instruments shall fulfil EN ISO 7726 (EN 12599).

8.4.3 Indoor air quality and ventilation

8.4.3.1 General

Indoor air quality and ventilation of building is evaluated with a representative sample taken from different air handling units and zones of the building.

8.4.3.2 Ventilation method

Ventilation of buildings can be evaluated by measuring air flows in ducts or tracer gas measurements.

8.4.3.3 Air quality method

Air quality of building can be evaluated in buildings where people are the main pollution source by measuring the average CO_2 concentration in the building, when building is fully occupied. This can be done either with representative samples of room air or by measuring the concentration of the exhaust air.

8.4.4 Lighting

Lighting quality of building is evaluated by measurement of illuminance. The verification procedure in Clause 6 of EN 12464-1:2002 shall be followed.

In specific cases also more qualitative aspects (UGR, Ra values and luminaire illuminance) can be evaluated by the procedure in Clause 6 of EN 12464-1:2002.

8.4.5 Noise

Noise is evaluated with a representative sample from different air handling systems, zones, windows, and orientation. Normally the criteria for noise do not influence the energy performance of buildings. It could, however, occur in naturally ventilated buildings, that the required amount of outside air cannot be obtained by opening of windows because noise from outside would violate the criteria. Also in the case of mechanical ventilation and cooling, providing the required amount of air would result in unacceptable noise levels from fans.

If adequate ventilation depends on the opening of the windows the equivalent sound pressure level (including the periods the windows are open and room is exposed to the outdoor noise) shall be used to evaluate the noise. The criteria for noise is given in Annex E.

8.5 Subjective evaluations

The direct subjective reaction of the occupants can be used for overall evaluation of the indoor environment. Daily, weekly, monthly evaluations using questionnaires for general acceptance of the indoor environment, thermal sensation, perceived air quality shall be used. In Annex H recommended procedures and questionnaires are given for logging subjective reactions.

9 Inspections and measurement of the indoor environment in existing buildings

9.1 General

Often it is necessary to perform measurements of the indoor environment of the building during inspection to be able to give advice regarding heating loads and system size and operation (article 8 of EPBD) and the cooling load and system size (article 9 of EPBD).

Requirements for inspection can be found at national level or in EN 15239, EN 15240 and prEN 15378.

If the inspection requires measurement of the indoor environment the following procedures shall be followed.

9.2 Measurements

9.2.1 General

In existing buildings measurements might be used to check whether the performance of the building and its building service systems (ventilation system, heating and cooling devices, artificial lighting) meet the design requirements. In the paragraphs below is indicated how such measurements can be conducted for each indoor environmental quality parameter.

9.2.2 Thermal environment

The measurement instrumentation used for evaluation of the thermal environment shall meet the requirements given in EN ISO 7726.

Comply with the recommendations given in EN ISO 7726 as far as the location of measurement instrumentation within the spaces is concerned.

Measurements shall be made where occupants are known to spend most of their time and under representative weather condition of cold and warm season. For the winter (heating season) measurements at or below mean outside temperatures for the 3 coldest months of the year, and for the summer (cooling season) measurements at or above statistic average outside temperatures for the 3 warmest months of the year with clear sky.

The measurement period for all measured parameters should be long enough to be representative, for example 10 days.

Air temperature in a room can be used in long term measurements and corrected for large hot or cold surfaces to estimate the operative temperature of the room.

9.2.3 Indoor air quality

Indoor air quality measurements are based on the indirect approach of measuring ventilation rates. Only if specific complaints (e.g. smell, sick building symptoms) persist and ventilation measurements show that the requirements for fresh air supply are met should measurements be made of specific pollutants (e.g. formaldehyde, other Volatile Organic Compounds, fine dust (PM 10 or PM 2,5)). How this should be done is outside the scope of this document.

An exception is the measurement of CO_2: In buildings where people are the main pollution sources the ventilation rates (per person or per m^2) can be derived using CO_2 measurement.

Measurements shall be made where occupants are known to spend most of their time, preferably at head level during typical high load conditions.

CO_2 measurements should preferably be made under winter conditions, as normally fresh air supply is lowest during the colder months (limited use of operable windows, partly closed facade shutters due to draught risk). In some cases momentary measurements at 'worst case times' (e.g. end of the morning or end of the afternoon in for example an office or school) might be sufficient.

In larger buildings not all rooms need to be evaluated and measurements in only 5 or 10% of the rooms (representatively chosen) might be enough.

In mechanically ventilated buildings measurement of the amount of fresh air supply is often more practical and precise than the measurement of CO_2 concentrations.

The measurement instrumentation used for evaluation of the air supply shall meet the requirements given in EN 12599.

First the total fresh air supply for the whole building should be measured and translated into an average per m^2 value. Also in a (representatively selected) sample of rooms (e.g. 5 or 10% of the total) the fresh air supply 'at room level' should be measured. The latter should be translated in both a fresh air supply per m^2 and a fresh air supply per person value, taking into account actual occupancy levels and design occupancy levels.

Measurements shall be made under 'semi-worst case weather conditions' which normally are the winter months. In many mechanically ventilated buildings in winter recirculation is used. Obviously the air supply at room level values should be corrected for recirculation during periods when recirculation is used.

When constant volume mechanical ventilation systems are used, instantaneous measurements are sufficient.

In buildings / spaces with variable volume systems the air supply (at room level) should be measured in both minimum and maximum position.

9.2.4 Lighting

Light quality measurements are based on measuring illuminance. The illuminance shall be measured on the task area to conform to values recommended in EN 12464-1 at all operational times. If specific complaints of glare persist and illuminance measurements show that the requirements for illuminance levels are met checks on specific qualities (UGR, Ra, etc) might be useful to check conformity with values recommended in EN 12464-1 at all operational times. How this should be done is outside the scope of this document. The measurement instrumentation for the evaluation of illuminance shall meet the requirements given in CIE 69.

The verification procedures in Clause 6 of EN 12464-1:2002 shall be followed.

The criteria shall be met at all material times. The measurement of illuminance shall also be made at times when daylight is not available but only if the building is used in the hours of darkness

The horizontal maintained illuminance shall be measured on the task area and in the task plane

Measurement should be carried in compliance with EN 13032.

10 Classification and certification of the indoor environment

10.1 General

The information of indoor environment of the building should be included with the energy certificate of the building (EPBD article 7) so that total performance of building can be evaluated. For this certificate the classification of indoor environment is necessary. For the certification it may be necessary to integrate complex indoor environment information into a simple overall indicator of indoor environmental quality of the building.

Due to the many parameters and insufficient knowledge on the combined influence of the indoor environmental parameters, it is recommended to make an overall classification based on only thermal environment and indoor air quality.

10.2 Detailed classification and certification

The evaluation of the indoor environment includes (1) thermal criteria for winter, (2) thermal criteria for summer, (3) air quality and ventilation criteria, (4) lighting criteria, (5) acoustic criteria. Classification of indoor environment can be based on showing the design criteria for each parameter, calculations or measurements over a time period (week, month, year) of relevant parameters like room temperature, ventilation rates, humidity, and CO2 concentrations. The basis of evaluation has to be specified in the classification and certification. An example is shown in Annex I.

10.3 Recommended overall evaluation of the indoor environment and certification

For the overall evaluation it is recommended that a comfort “foot-print” is given for thermal conditions and indoor air quality conditions separately. This can be shown as the percentage of time the indoor environment (temperatures, ventilation rates or CO_2 concentrations are within the different categories (I, II, III, and IV). Examples are included in Annex I.

Annex A
(informative)

Recommended criteria for the thermal environment

A.1 Recommended categories for design of mechanical heated and cooled buildings

Assuming different criteria for the PPD-PMV (EN ISO 7730) different categories of the indoor environment are established. Recommended PPD ranges are given in Table A.1 below. The PMV-PPD index takes into account the influence of all 6 thermal parameters (clothing, activity, air- and mean radiant temperature, air velocity and humidity) and can be directly used as criteria. By an assumed combination of activity and clothing, an assumed 50 % relative humidity and low air velocities it is possible to establish a corresponding range of operative temperatures and express the criteria as a temperature range. For the design and dimensioning further criteria for the thermal environment (draught, vertical air temperature differences, floor temperature, and radiant temperature asymmetry) should be taken into account (see EN ISO 7730).

Table A.1 — Examples of recommended 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
IV	> 15	PMV<-0,7; or +0,7<PMV

Assumed clothing level for winter and summer (clo-value) and activity level (met-value) are listed in the table. The temperatures in Table A.2 are operative temperatures (EN ISO 7726) with design loads at the design weather conditions which are specified nationally according to EN ISO 15927- 4 and 5. In most cases the average room air temperature can be used as defining the design temperature, but if temperatures of large room surfaces differ significantly from the air temperature the operative temperature should be used. Further information on clothing and activity can be found in EN ISO 9920 and EN ISO 8996. The value of design temperature can vary from the values shown to take account of e.g. local custom or a desire for energy saving so long as the within-day variation from the design temperature is within the given range, and the occupants are given time and opportunity to adapt to the modified design temperature.

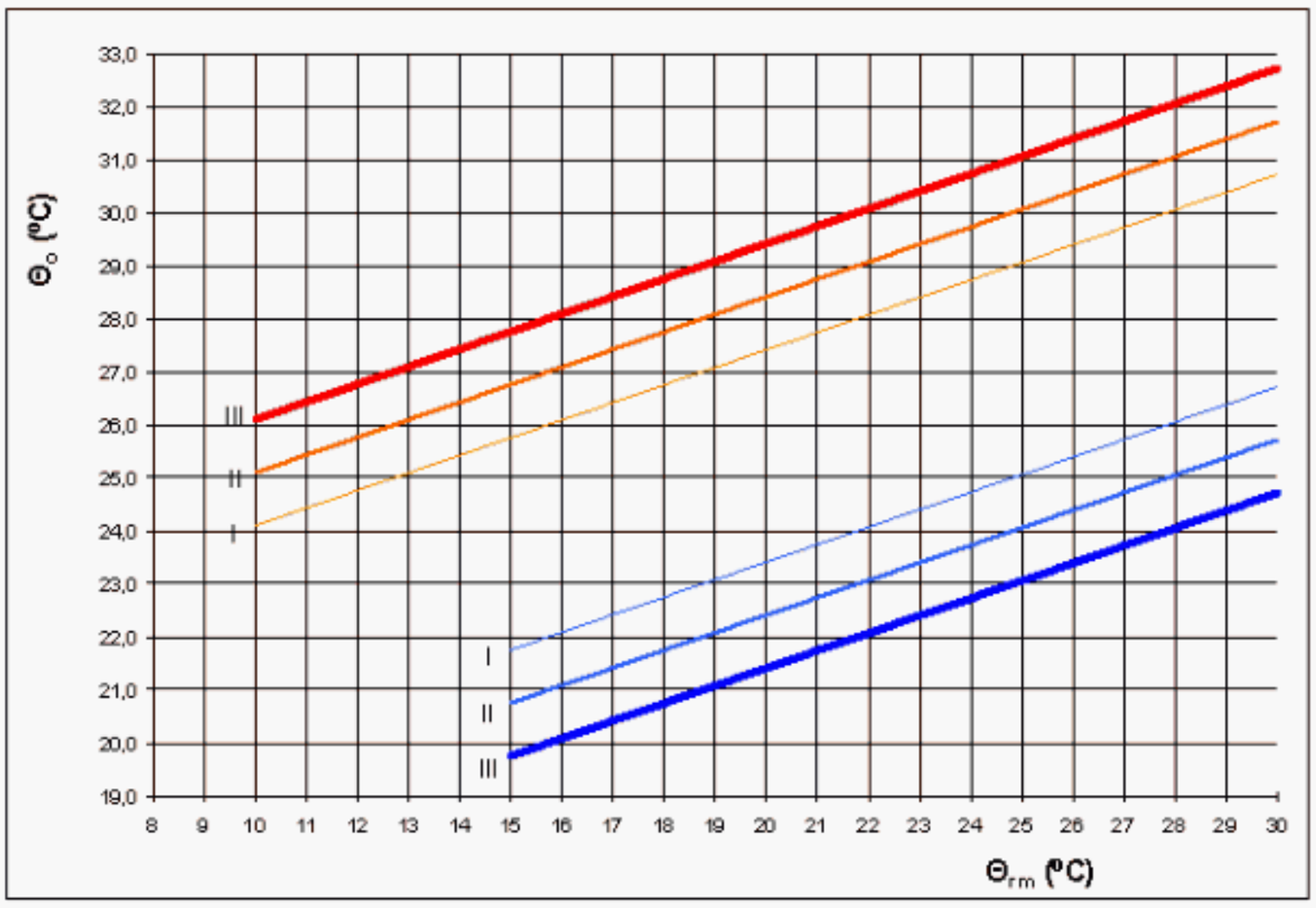
Table A.2 — Examples of recommended design values of the indoor temperature for design of buildings and HVAC systems

Type of building/ space	Category	Operative temperature °C	
		Minimum for heating (winter season), ~ 1,0 clo	Maximum for cooling (summer season), ~ 0,5 clo
Residential buildings: living spaces (bed rooms, drawing room, kitchen etc)	I	21,0	25,5
	II	**20,0**	**26,0**
Sedentary ~ 1,2 met	III	18,0	27,0
Residential buildings: other spaces: storages, halls, etc)	I	18,0	
	II	**16,0**	
Standing-walking ~ 1,6 met	III	14,0	
Single office (cellular office)	I	21,0	25,5
Sedentary ~ 1,2 met	**II**	**20,0**	**26,0**
	III	19,0	27,0
Landscaped office (open plan office)	I	21,0	25,5
Sedentary ~ 1,2 met	**II**	**20,0**	**26,0**
	III	19,0	27,0
Conference room	I	21,0	25,5
Sedentary ~ 1,2 met	**II**	**20,0**	**26,0**
	III	19,0	27,0
Auditorium	I	21,0	25,5
Sedentary ~ 1,2 met	**II**	**20,0**	**26,0**
	III	19,0	27,0
Cafeteria/Restaurant	I	21,0	25,5
Sedentary ~ 1,2 met	**II**	**20,0**	**26,0**
	III	19,0	27,0
Classroom	I	21,0	25,0
Sedentary ~ 1,2 met	**II**	**20,0**	**26,0**
	III	19,0	27,0
Kindergarten	I	19,0	24,5
Standing/walking ~ 1,4 met	**II**	**17,5**	**25,5**
	III	16,5	26,0
Department store	I	17,5	24,0
Standing-walking ~ 1,6 met	**II**	**16,0**	**25,0**
	III	15,0	26,0

A.2 Acceptable indoor temperatures for design of buildings without mechanical cooling systems

In Figure A.1 acceptable 'summer' indoor temperatures (cooling season) are presented for buildings without mechanical cooling systems.

The operative temperatures (room temperatures) presented in Figure A.1 are valid for office buildings and other buildings of similar type used mainly for human occupancy with mainly sedentary activities and dwelling, where there is easy access to operable windows and occupants may freely adapt their clothing to the indoor and/or outdoor thermal conditions.



Key

Θ_{rm} = Outdoor Running mean temperature °C.

Θ_0 = Operative temperature °C.

Figure A1 - Design values for the indoor operative temperature for buildings without mechanical cooling systems as a function of the exponentially-weighted running mean of the outdoor temperature

The temperature limits only apply when the thermal conditions in the spaces at hand are regulated primarily by the occupants through opening and closing of windows. Several field experiments have shown that occupants' thermal responses in such spaces depends in part on the outdoor climate, and differ from the thermal responses of occupants in buildings with HVAC systems, mainly because of differences in thermal experience, availability of control and shifts in occupants' expectations.

In order for this optional method to apply, the spaces in question shall be equipped with operable windows which open to the outdoors and which can be readily opened and adjusted by the occupants of the spaces.

There shall be no mechanical cooling in operation in the space. Mechanical ventilation with unconditioned air (in summer) may be utilized, but opening and closing of windows shall be of primary importance as a means of regulating thermal conditions in the space. There may in addition be other low-energy methods of personally controlling the indoor environment such as fans, shutters, night ventilation etc. The spaces may be provided by a heating system, but this optional method does not apply during times of the year when the heating system is in operation when A.1 applies.

This optional method only applies to spaces where the occupants are engaged in near sedentary physical activities with metabolic rates ranging from 1,0 to 1,3 met. It is also important that strict clothing policies inside the building are avoided, in order to allow occupants to freely adapt their clothing insulation.

The (summer) temperature limits presented in this annex are primarily based on studies in office buildings. Nevertheless, based on general knowledge on thermal comfort and human responses, the assumption can be made that the limits may apply to other (comparable) buildings with mainly sedentary activities like residential buildings. Especially in residential buildings the opportunities for (behavioural) adaptation are relatively wide: one is relatively free to adjust metabolism and the amount of clothing worn dependant on outside weather conditions and indoor temperatures.

The temperature limits in Figure A.1 are based on comfort studies in offices, which did not take peoples work performance into account.

In landscaped (open plan) offices most occupants have only limited access to operable windows and therefore poor control over natural ventilation. Therefore: the temperature limits presented in this annex may not always apply in such situations.

The figure includes 3 categories of temperature limits for use as outlined in the introduction and Clause 5 to this standard. The allowable indoor operative temperatures of Figure A.1 are plotted against the external running mean temperature Θ_{rm}. This is defined as the exponentially weighted running mean of the daily outdoor temperature (see equations (2) and (3) in the definition section for methods to calculate Θ_{rm})

The equations representing the lines in Figure A.1 are

Category I	upper limit:	$\Theta_{i\,max} = 0{,}33\Theta_{rm} + 18{,}8 + 2$
	lower limit:	$\Theta_{i\,min} = 0{,}33\,\Theta_{rm} + 18{,}8 - 2$
Category II	upper limit:	$\Theta_{i\,max} = 0{,}33\,\Theta_{rm} + 18{,}8 + 3$
	lower limit:	$\Theta_{i\,min} = 0{,}33\,\Theta_{rm} + 18{,}8 - 3$
Category III	upper limit:	$\Theta_{i\,max} = 0{,}33\,\Theta_{rm} + 18{,}8 + 4$
	lower limit:	$\Theta_{i\,min} = 0{,}33\,\Theta_{rm} + 18{,}8 - 4$

where Θ_i = limit value of indoor operative temperature, °C

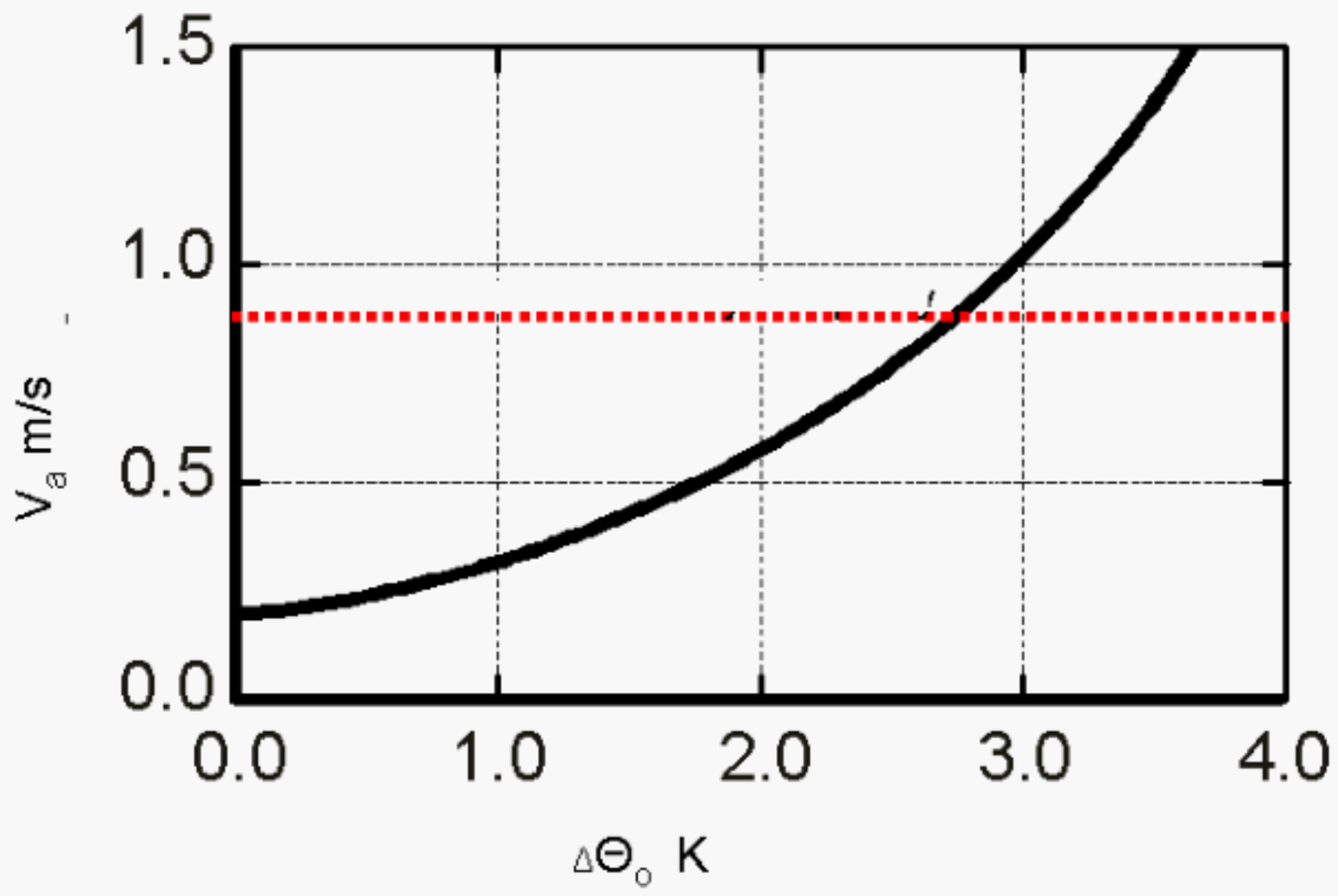
Θ_{rm} = running mean outdoor temperature. These limits apply when 10 <Θ_{rm} < 30 °C for upper limit and 15 <Θ_{rm} < 30 °C for lower limit. Above 25 °C the graphs are based on a limited database.

The following temperature limits that should be applied in the heating season in buildings without mechanical cooling systems: below an outdoor running mean temperature of 10 °C use for the upper limits the same (I, II, III) values as for mechanically cooled buildings (winter upper temperature, see 6.2.1); below an outdoor running mean temperature of 15 °C use for the *lower* limits the same (I, II, III) values as for mechanically cooled buildings (winter under temperature, see 6.2.1).

The temperature limits presented in A.2 should be used for the dimensioning of passive means to prevent overheating in summer conditions e.g. dimensions and the orientation of windows, dimensions of solar shading and the thermal capacity of the building's construction. Where the adaptive temperature limits presented in A.2 (upper limits) cannot be guaranteed by passive means mechanical cooling is unavoidable. In such cases the design criteria for buildings WITH mechanical cooling should be used.

Note that Figure A.1 already accounts for people's clothing adaptation; therefore it is not necessary to estimate the clothing values when using the alternative method presented in this annex.

Under 'summer comfort conditions' (indoor operative temperatures > 25 ºC) increased air velocity may be used to compensate for increased air temperatures. Where there are fans (that can be controlled directly by occupants) or other means for personal air speed adjustment (e.g. Personal Ventilation systems) the upper limits presented in Figure A.1 can be increased by a few degrees. The exact temperature correction depends upon the air speed that is generated by the fan and can be derived from Figure A.2. This method can also be used to overcome excessive temperatures in mechanically controlled buildings if the local method for controlling air movement (fan etc) is available.



Key

$\Delta\Theta_o$ = Increase in operative temperature, K

V_a = Air speed, m/s

Figure A2 - Air speed required to offset increased temperature (EN ISO 7730). The air speed increases by the amount necessary to maintain the same total heat transfer from the skin. Acceptance of the increased air speed will require occupant control of device creating the local air speed.

A.3 Recommended indoor temperatures for energy calculations

Table A.3 — Temperature ranges for hourly calculation of cooling and heating energy in three categories of indoor environment

Type of building or space	Category	Temperature range for heating, °C Clothing ~ 1,0 clo	Temperature range for cooling, °C Clothing ~ 0,5 clo
Residential buildings, living spaces (bed room's living rooms etc.) Sedentary activity ~1,2 met	I	21,0 -25,0	23,5 - 25,5
	II	**20,0-25,0**	**23,0 - 26,0**
	III	18,0- 25,0	22,0 - 27,0
Residential buildings, other spaces (kitchens, storages etc.) Standing-walking activity ~1,5 met	I	18,0-25,0	
	II	**16,0-25,0**	
	III	14,0-25,0	
Offices and spaces with similar activity (single offices, open plan offices, conference rooms, auditorium, cafeteria, restaurants, class rooms, Sedentary activity ~1,2 met	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
Kindergarten Standing-walking activity ~1,4 met	I	19,0 – 21,0	22,5 - 24,5
	II	**17,5 – 22,5**	**21,5 – 25,5**
	III	16,5 – 23,5	21,0 - 26,0
Department store Standing-walking activity ~1,6 met	I	17,5 – 20,5	22,0 - 24,0
	II	**16,0 – 22,0**	**21,0– 25,0**
	III	15,0 – 23,0	20,0 - 26,0

As noted in clause A.1 the mean design temperature can vary from the values shown to take account of e.g. local custom or a desire for energy saving so long as the within-day variation from the design temperature is within the given range, and the occupants are given time and opportunity to adapt to the modified design temperature.

Annex B
(informative)

Basis for the criteria for indoor air quality and ventilation rates

B.1 Recommended design ventilation rates in non-residential buildings

B.1.1 General

There does not exist a common standard index for the indoor air quality. The indoor air quality is then expressed as the required level of ventilation or CO_2 concentrations. It is general accepted that the indoor air quality is influenced by emission from people and their activities (bio effluent, smoking), from building and furnishing, and from the HVAC system itself. The two last sources are normally called the building components. The required ventilation is based on health and comfort criteria. In most cases the health criteria will also be met by the required ventilation for comfort. Health effects may be attributed to specific components of emission and if you reduce concentration of one source you also reduce concentration of others. Comfort is more related to the perceived air quality (odour, irritation). In this case different sources of emission may have an odour component that adds to the odour level. There his however no general agreement how different sources of emission should be added together. In the present standard the criteria will in the following be expressed in different ways.

B.1.2 Calculating required ventilation for people component (smoking, non-smoking) and add the required ventilation for the building component.

B.1.3 Calculate the required ventilation rate per person or per square meter floor area.

B.1.4 Calculate the required ventilation rate based on a mass balance and required criteria for the CO_2 level

B.1.2 Method based on person and building component

The calculated design ventilation rate is from two components (a) ventilation for pollution from the occupants (bio effluents) and (b) ventilation for the pollution from the building and systems. The ventilation for each category is the sum of these two components as illustrated with the equation (B.1).

The ventilation rates for occupants (q_p) only are listed in Table B.1:

Table B.1 — Basic required ventilation rates for diluting emissions (bio effluents) from people for different categories

Category	Expected Percentage Dissatisfied	Airflow per person l/s/pers
I	15	1O
II	20	7
III	30	
IV	> 30	< 4

The ventilation rates (q_B) for the building emissions are:

	Very low polluting building	Low polluting building	Non low-polluting building
Category I:	0,5 l/s, m^2	1,0 l/s, m^2	2,0 l/s, m^2
Category II:	**0,35 l/s, m^2**	**0,7 l/s, m^2**	**1,4 l/s, m^2**
Category III:	0,3 l/s, m^2	0,4 l/s, m^2	0,8 l/s, m^2

Total ventilation rate for a room is calculated from the following formula

$$q_{tot} = n \cdot q_p + A \cdot q_B \qquad \text{(B.1)}$$

Where:

q_{tot}= total ventilation rate of the room, 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= room floor area, m^2

q_B = ventilation rate for emissions from building, l/s,m^2

Examples of the total ventilation rates for non-industrial, non-residential buildings based on these values are calculated using Equation (B.1) with default occupancy densities indicated in Table B.2. The values in the table are based on complete mixing in the room (concentration of pollutants is equal in exhaust and in occupied zone). Ventilation rates can be adjusted according to the ventilation efficiency if the performance of air distribution differs from complete mixing, and can be reliably proven (EN 13779). The ventilation required for smoking is based on the assumption that 20 % of occupants are smokers smoking and smoke 1,2 cigarettes per hour. For higher rate of smoking the ventilation rates should be increased proportionally. Ventilation rates for smoking are based on comfort, not on health criteria.

A building is called low-polluting or very low-polluting, when the majority of building materials used for finishing the interior surfaces meet the national or international criteria of low-polluting or very low-polluting materials. An example of how to define low-polluting and very low-polluting building materials is given in Annex C.

Table B.2 — Examples of recommended ventilation rates for non-residential buildings with default occupant density for three categories of pollution from building itself. If smoking is allowed the last column gives the additional required ventilation rate.

Type of building or space	Cate-gory	Floor area m^2/per-son	q_p	q_B	q_{tot}	q_B	q_{tot}	q_B	q_{tot}	Add when smoking
			l/s, m^2 for occupancy	l/s,m^2 for very low-polluted building		l/s,m^2 for low-polluted building		l/s,m^2 for non-low polluted building		l/s,m^2
Single office	I	10	1,0	0,5	1,5	1,0	2,0	2,0	3,0	0,7
	II	**10**	**0,7**	**0,3**	**1,0**	**0,7**	**1,4**	**1,4**	**2,1**	**0,5**
	III	10	0,4	0,2	0,6	0,4	0,8	0,8	1,2	0,3
Land-scaped office	I	15	0,7	0,5	1,2	1,0	1,7	2,0	2,7	0,7
	II	**15**	**0,5**	**0,3**	**0,8**	**0,7**	**1,2**	**1,4**	**1,9**	**0,5**
	III	15	0,3	0,2	0,5	0,4	0,7	0,8	1,1	0,3
Conference room	I	2	5,0	0,5	5,5	1,0	6,0	2,0	7,0	5,0
	II	**2**	**3,5**	**0,3**	**3,8**	**0,7**	**4,2**	**1,4**	**4,9**	**3,6**
	III	2	2,0	0,2	2,2	0,4	2,4	0,8	2,8	2,0
Auditorium	I	0,75	15	0,5	15,5	1,0	16	2,0	17	
	II	**0,75**	**10,5**	**0,3**	**10,8**	**0,7**	**11,2**	**1,4**	**11,9**	
	III	0,75	6,0	0,2	0,8	0,4	6,4	0,8	6,8	
Restaurant	I	1,5	7,0	0,5	7,5	1,0	8,0	2,0	9,0	
	II	**1,5**	**4,9**	**0,3**	**5,2**	**0,7**	**5,6**	**1,4**	**6,3**	**5,0**
	III	1,5	2,8	0,2	3,0	0,4	3,2	0,8	3,6	2,8
Class room	I	2,0	5,0	0,5	5,5	1,0	6,0	2,0	7,0	
	II	**2,0**	**3,5**	**0,3**	**3,8**	**0,7**	**4,2**	**1,4**	**4,9**	
	III	2,0	2,0	0,2	2,2	0,4	2,4	0,8	2,8	
Kindergarten	I	2,0	6,0	0,5	6,5	1,0	7,0	2,0	8,0	
	II	**2,0**	**4,2**	**0,3**	**4,5**	**0,7**	**4,9**	**1,4**	**5,8**	

	III	2,0	2,4	0,2	2,6	0,4	2,8	0,8	3,2	
Department store	I	7	2,1	1,0	3,1	2,0	4,1	3,0	5,1	
	II	**7**	**1,5**	**0,7**	**2,2**	**1,4**	**2,9**	**2,1**	**3,6**	
	III	7	0,9	0,4	1,3	0,8	1,7	1,2	2,1	

B.1.3 Method based on ventilation rate per person or per m^2 floor area

Table B.3 lists for different categories the recommended ventilation rates expressed either per person or per square meter floor area.

The values per person assume that occupants are the only source of pollution. The values per floor area assume only the pollutions from material emissions. Ventilation in the building shall be designed considering all sources of pollutions present. Though, different methods are possible to use in this objective, sometimes addition of the values (see B.1.2), sometimes the highest value (maximum of the calculated value based on per person and the value based on per m² floor area from Table B.3) and sometimes a value between the highest value and the value based on addition (Table B.2). When national regulations don't decide it, the designer shall make his own decision and report it.

Table B.3 — Examples of recommended ventilation rates for non-residential buildings for three categories of pollution from building itself. Rates are given per person or per m^2 floor area

		Airflow for building emissions pollutions (l/s/m²)		
Category	Airflow per person l/s/pers	Very low polluting building	Low polluting building	Non low polluting building
I	1O	0,5	1	2
II	7	0,35	0,7	1,4
III	4	0,2	0,4	0,8

Table B.4 — Examples of recommended CO_2 concentrations above outdoor concentration for energy calculations and demand control

Category	Corresponding CO_2 above outdoors in PPM for energy calculations
I	350
II	500
III	800
IV	< 800

B.1.4 Recommended values of CO_2 for energy calculation

The required ventilation rates can also be calculated based on a mass balance equation for the CO_2 concentration (EN 13779) taking into account the outdoor CO_2 concentration. Recommended criteria for the CO_2 calculation are included in B.4. The listed CO_2 values can also be used for Demand Control Ventilation.

If ventilation is controlled automatically (DCV) the maximum design ventilation rate has to correspond to the calculated maximum concentration of pollutant. The ventilation rate may vary between the maximum and minimum ventilation rates specified, however, the specified minimum ventilation rate shall be provided during occupancy.

B.2 Recommended design ventilation rates in residential buildings

IAQ achieved depends mainly on three criteria:

- Exhaust of pollutions in wet rooms (bathroom, kitchen, toilets).
- General ventilation of all rooms in the dwelling.
- General ventilation of all rooms in the dwelling with fresh air criteria in the main room (bed and living rooms).

It is admitted that some factors in these regulations have generally an impact on achieved IAQ. For instance, the criteria may be expressed by 3 different methods:

- Requiring exhaust in the wet rooms is necessary to remove local pollutions in these areas (depression is also necessary).
- Requiring general ventilation (all rooms to be ventilated). This requirement is generally also allowing some transfer from main living rooms (living and diner room, bedrooms..) via corridors to wet rooms (kitchens, bathrooms, toilets).

- Some regulations consider the overall ventilation rate in the building, others have added emphasize on the minimum supply air per bed and living room. This addition allows for the same overall level a better IAQ because systems have to adapt and deliver in the appropriate room where the real occupation is.

The indoor air quality is expressed as the required level of ventilation. For Demand Controlled Ventilation, equivalences have to be defined at National level. The criteria will in the following be expressed in different ways (see Table B.5).

The ventilation air flows of the bedrooms and living rooms for general ventilation in the dwelling are expressed as:

- air change per hour for each room and/or outside air supply to achieve a requirement in the main rooms. When choosing this option, it is generally required to achieve also one of the two following criteria to deal with pollution in the wet rooms;

- required exhaust rates (bathroom, toilets, and kitchens).

The supply air to kitchens, bathrooms and toilets may be the transfer air from the bedrooms and living rooms.

Table B.5 — Example of ventilation rates for the residences. Continuous operation of ventilation during occupied hours. Complete mixing

Category	Air change rate [a]		Living room and bedrooms, mainly outdoor air flow		Exhaust air flow, l/s		
	l/s,m^2 (1)	ach	l/s, pers[b] (2)	l/s/m^2 (3)	Kitchen (4a)	Bathrooms (4b)	Toilets (4)
I	0,49	0,7	10	1,4	28	20	14
II	0,42	0,6	7	1,0	20	15	10
III	0,35	0,5	4	0,6	14	10	7

[a] The air change rates expressed in l/sm^2 and ach correspond to each other when the ceiling height is 2,5 m.

[b] The number of occupants in a residence can be estimated from the number of bedrooms. The assumptions made at national level have to be used when existing; they may vary for energy and for IAQ calculations.

Example of procedure for selecting the ventilation rate:

When the values of any specific category in the table leads different values of the ventilation depending on the number of occupants, floor area and number of kitchen, bathroom and toilet exhausts the following principle should be followed:

1) Calculate total ventilation rate for the residence based on:

a. Floor area, column (1).

b. Number of occupants or number of bedrooms, column (2) and (3).

2) Select the higher value from above a) or b) for the total ventilation rate of the residence

3) Adjust the exhaust air flows from the kitchen, bathroom and toilets, columns (4) accordingly:

a. in residences with small floor area exhaust air flow rates become smaller;

b. in large residences higher.

4) Outdoor air should be supplied primarily to living rooms and bedrooms

The values in the table assume complete mixing in the room (i.e. concentration of pollutants is equal in exhaust and in occupied zone).

B.3 Recommended criteria for dimensioning of humidification and de-humidification

If humidification or dehumidification is used the values in Table B.6 is recommended as design values under design conditions. Usually humidification or dehumidification is needed only in special buildings like museums, some health care facilities, process control, paper industry etc.

Besides it is recommended to limit the absolute humidity to 12g/kg.

Table B.6 — Example of recommended design criteria for the humidity in occupied spaces if humidification or dehumidification systems are installed

Type of building/space	Category	Design relative humidity for dehumidification, %	Design relative humidity for humidification, %
Spaces where humidity criteria are set by human occupancy. Special spaces (museums, churches etc) may require other limits	I	50	30
	II	60	25
	III	70	20
	IV	> 70	< 20

B.4 Recommended ventilation during un-occupied hours

Non-Residential buildings

Outdoor air flow equivalent to 2 air volumes of the ventilated space shall be delivered to the space before occupancy (e.g. if the ventilation rate is 2 ach the ventilation is started one hour before the occupancy). Infiltration can be calculated as a part of this ventilation (leakage assumptions should be described).

Instead of pre-start of the ventilation system, buildings to be ventilated during the unoccupied periods, with lower ventilation rate than during the occupied period. The minimum ventilation rate shall be defined based on building type and pollution load of the spaces. A minimum value of 0,1 to 0,2 $l/s,m^2$ is recommended if national requirements are not available.

Residential buildings

In residential building, “unoccupied periods” means mainly periods when there is no demand.

A minimum ventilation rate between 0,05 to 0,1 l/sm^2 during un-occupied hours is recommended if no value is given at national level.

Annex C
(informative)

Example on how to define low and very low polluting buildings

The building is low polluting if the majority of the materials are low polluting. Low polluting materials are natural traditional materials, such as stone and glass, which are known to be safe with respect to emissions, and materials which fulfil the following requirements:

- Emission of total volatile organic compounds (TVOC) is below 0,2 mg/m²h.
- Emission of formaldehyde is below 0,05 mg/m²h.
- Emission of ammonia is below 0,03 mg/m²h.
- Emission of carcinogenic compounds (IARC) is below 0,005 mg/m²h.
- Material is not odorous (dissatisfaction with the odour is below 15 %).

The building is very low polluting if all of the materials are very low polluting and smoking has never occurred and is not allowed. Very low polluting materials are natural traditional materials, such as stone, glass and metals, which are known to be safe with respect to emissions, and materials which fulfil the following requirements:

- Emission of total volatile organic compounds (TVOC) is below 0,1 mg/m²h.
- Emission of formaldehyde is below 0,02 mg/m²h.
- Emission of ammonia is below 0,01 mg/m²h.
- Emission of carcinogenic compounds (IARC) is below 0,002 mg/m²h.
- Material is not odorous (dissatisfaction with the odour is below 10 %).

Annex D
(informative)

Recommended criteria for lighting

Table D.1 — Examples of design illumination levels for some buildings and spaces from EN 12464-1. For information purposes the UGR and Ra are also presented.

Type of building	Space	Maintained illuminance, $\hat{E}_m$, at working areas, *l*x	UGR	Ra	Remarks
Office buildings	Single offices	500	19	80	at 0,8 m
	Open plan offices	500	19	80	at 0,8 m
	Conference rooms	500	19	80	at 0,8 m
Educational buildings	Classrooms	300	19	80	at 0,8 m
	Classrooms for adult education	500	19	80	at 0,8 m
	Lecture hall	500	19	80	at 0,8 m
Hospitals	General ward lighting	100	19	80	at 0,8 m
	Simple examination	300	19	80	at 0,8 m
	Examination and treatment	1000	19	90	at 0,8 m
Hotels and restaurants	Restaurant, dining room	-	-	80	at 0,8 m
Sport facilities	Sports halls	300	22	80	at 0,1 m
Wholesale and retail premises	Sales area	300	22	80	at 0,8 m
	Till area	500	19	80	at 0,8 m
Circulation areas	Corridor	100	28	40	at 0,1 m
	Stairs	150	25	40	at 0,1 m
Other buildings	See EN 12464-1				

Annex E
(informative)

Indoor system noise criteria of some spaces and buildings

Table E.1 — Examples of design A-weighted sound pressure level

Building	Type of space	Sound pressure level [dB(A)]	
		Typical range	Default design value
Residential	Living room	25 to 40	32
	Bed room	20 to 35	26
Child care institutions	Nursery schools	30 to 45	40
	Day nurseries	30 to 45	40
Places of assembly	Auditoriums	30 to 35	33
	Libraries	28 to 35	30
	Cinemas	30 to 35	33
	Court rooms	30 to 40	35
	Museums	28 to 35	30
Commercial	Retail shops	35 to 50	40
	Department stores	40 to 50	45
	Supermarkets	40 to 50	45
	Computer rooms, large	40 to 60	50
	Computer rooms, small	40 to 50	45
Hospitals	Corridors	35 to 45	40
	Operating theatres	30 to 48	40
	Wards	25 to 35	30
	Bedrooms night-time	20 to 35	30
	Bedrooms daytime	25 to 40	30
Hotels	Lobbies	35 to 45	40
	Reception rooms	35 to 45	40
	Hotel rooms (during night-time)	25 to 35	30
	Hotel rooms (during daytime)	30 to 40	35
Offices	Small offices	30 to 40	35
	Conference rooms	30 to 40	35
	Landscaped offices	35 to 45	40
	Office cubicles	35 to 45	40
Restaurants	Cafeterias	35 to 50	40
	Restaurants	35 to 50	45
	Kitchens	40 to 60	55
Schools	Classrooms	30 to 40	35
	Corridors	35 to 50	40
	Gymnasiums	35 to 45	40
	Teacher rooms	30 to 40	35
Sport	Covered sports stadiums	35 to 50	45
	Swimming baths	40 to 50	45
General	Toilets	40 to 50	45
	Cloakrooms	40 to 50	45

Annex F
(informative)

Long term evaluation of the general thermal comfort conditions

To evaluate the comfort conditions over time (season, year) a summation of parameters shall be made based on data measured in real buildings or dynamic computer simulations. This annex lists five methods, which can be used for that purpose.

Method A Percentage outside the range:

Calculate the number or % of occupied hours (those during which the building is occupied) when the PMV or the operative temperature is outside a specified range.

Method B Degree hours criteria:

The time during which the actual operative temperature exceeds the specified range during the occupied hours is weighted by a factor which is a function depending on by how many degrees, the range has been exceeded.

1. The weighing factor, *wf*, equals 0 for

   $\Theta_{o,limit,lower} \leq \Theta_o \leq \Theta_{o,limit,upper}$

   where $\Theta_{o,limit}$ is the lower or upper limit of the comfort range specified (e.g. 23,0°C $\leq \Theta_o \leq$ 26,0°C corresponding to –0,5 < PMV < 0,5 as specified in Annex A for single offices, category A, summer).

2. The weighing factor, *wf,* is calculated as

   $wf = \Theta_o - \Theta_{o,limit}$ I

   when $\Theta_o < \Theta_{o,limit,lower}$ <u>or</u> $\Theta_{o,limit,upper} < \Theta_o$

3. For a characteristic period during a year, the product of the weighting factor and time is summed. The summation of the product has the unit of hours

   Warm period:

   $\Sigma\, wf \cdot$ time for $\Theta_o > \Theta_{o,limit,upper}$

   Cold period:

   $\Sigma\, wf \cdot$ time for $\Theta_o < \Theta_{o,limit,lower}$

Method C PPD weighted criteria:

The time during which the actual PMV exceeds the comfort boundaries is weighted by a factor which is a function of the PPD. Starting from a PMV-distribution on a yearly basis and the relation between PMV and PPD the following is calculated:

1 The weighing factor, *wf*, equals 0 for

$PMV_{limit,lower} \leq PMV < PMV_{limit,upper}$

where PMV_{limit} is determined by the comfort range specified according to Annex A.

2 The weighting factor, *wf*, is calculated as

$$wf = \frac{PPD_{actualPMV}}{PPD_{PMVlimit}}$$

When

$PMV < PMV_{limit,lower}$ or $PMV_{limit,upper} < PMV$

in which

$PPD_{actualPMV}$ = the PPD corresponding to the actual PMV

$PPD_{PMVlimit}$ = the PPD corresponding to PMV_{limit}

3 The product of the weighing factor and the time is summed for a characteristic working period during a year. The summation of the product has the unit of

Warm period:

$\Sigma\, wf \cdot$ time for $PMV > PMV_{limit,upper}$

Cold period:

$\Sigma\, wf \cdot$ time for $PMV < PMV_{limit,lower}$

Table F.1 illustrates this concept of method B and C. The weighting factors are based on temperature difference *wf* (°C) and PPD; *wf* (PPD) is shown for a comfort range of 23-26°C, corresponding to sedentary work (1.2 met) and light summer clothing (0.5 clo). For temperatures above or below this interval, the number of hours will be multiplied with these factors. It will be seen that using the PPD weighting factor will result in a higher number of hours. The values may be used for the evaluation of long-term comfort conditions.

Add PPD values in the table so that reader can follow how the weighting factor are calculated

Table F.1 — Examples of weighting factors based on temperature difference or PPD for mechanically heated or cooled buildings following the assumptions shown in the text

Temperature °C		PPD %	Weighting factors	
			wf(°C)	wf(PPD)
Cool	20	47	3	4,7
	21	31	2	3,1
	22	19	1	1,9
Neutral	23	10	0	0
	24	<10	0	0
	25	<10	0	0
	26	10	0	0
Warm	27	19	1	1,9
	28	31	2	3,1
	29	47	3	4,7

Temperature °C		Weighting factors	
		Wf (°C)	*Wf* (PPD)
Cool	20	3	4,7
	21	2	3,1
	22	1	1,9
Neutral	23	0	0
	24	0	0
	25	0	0
	26	0	0
Warm	27	1	1,9
	28	2	3,1
	29	3	4,7

Annex G
(informative)

Recommended criteria for acceptable deviations

G.1 Building Category

The different parameters for the indoor environment of the building meet the criteria of a specified category when:

The parameter in the rooms representing 95 % of the occupied space is not more than as example 3 % (or 5 %) of occupied hours a day, a week, a month and a year outside the limits of the specified category (Annex A and B).

Examples of methods to evaluate long term performance of building are given in Annex F.

G.2 Length of deviation

The following table show the time which corresponds to a 3 % (5 %) deviation based on working hours and total hours.

Table G.1 — Examples of length of deviations corresponding to 3 and 5 % of time

3% / 5% of period	Daily min.	Weekly hours	Monthly hours	Yearly hours	
Working hours	15/24	1/2	5/9	61/108	
Total hours	43/72	5/9	22/36	259/432	

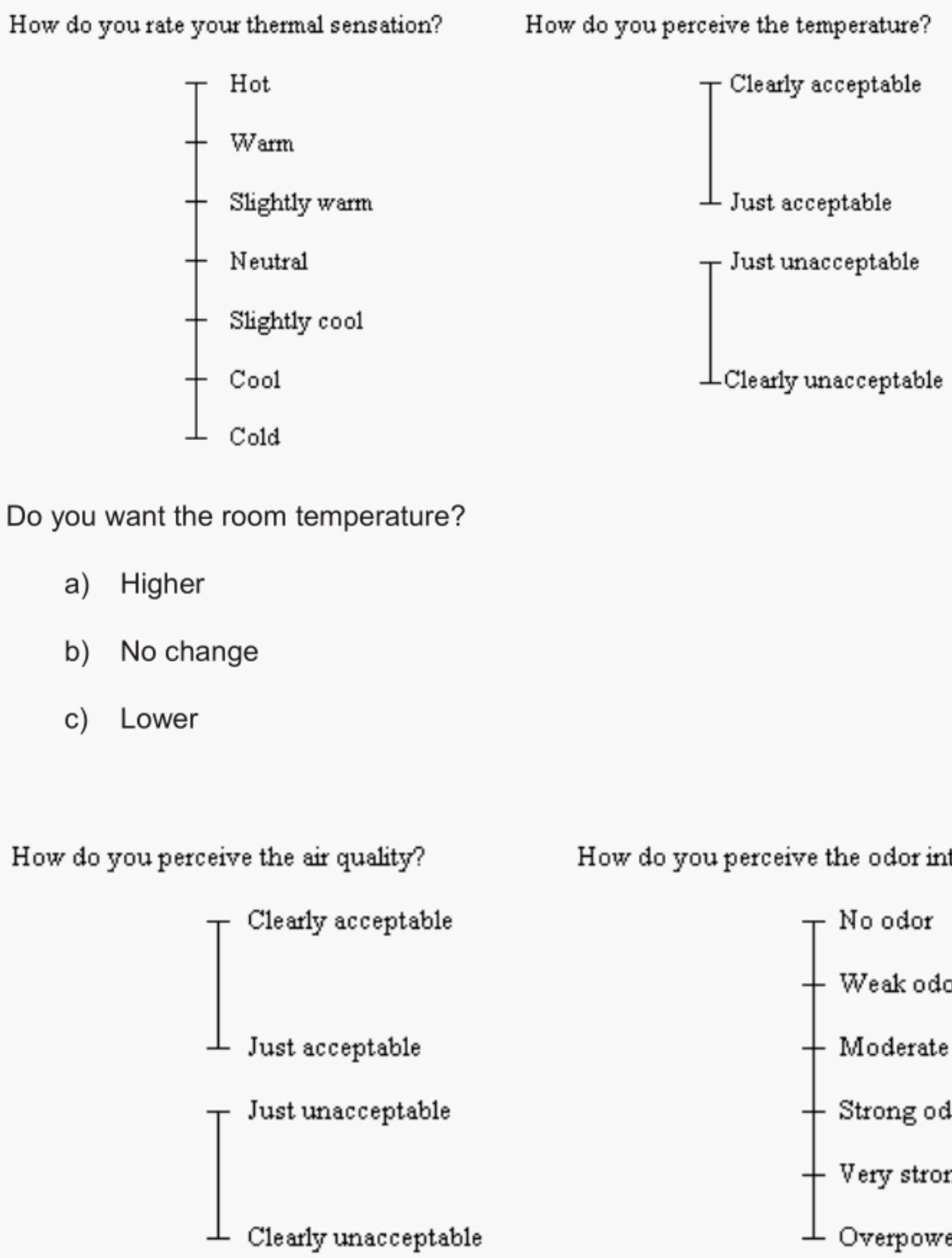
This allows for short time deviations f. ex. When opening windows, where short time increased air velocity and noise will be accepted. As example it is allowed on the 5 % level to have temperatures above the criteria for 108 h during a year but not more than 24 min during a working day and 2 h during a working week.

Annex H
(informative)

Methodologies for subjective evaluations

Subjective questionnaires can be used to evaluate the indoor environment. Subjective scales are presented to the occupants at fixed time intervals (daily, weekly, monthly, etc.). The scales can be presented through intranet on each persons PC or handed out as hard copies. The questionnaires should be filled out during middle morning or middle afternoon. Not just after arrival or after a lunch break. The results can be presented as average values and/or distributions. See example in Annex I.

Figure H.1 - Examples of questionnaires for subjective evaluations



Annex I
(informative)

Examples of classification and certification of the indoor environment

The indoor environment in a building may be classified by:

a) Criteria used for energy calculations (new buildings).

b) Whole year computer simulations of the indoor environment and energy performance (new and existing buildings).

c) Long term measurement of selected parameters for the indoor environment (existing buildings).

d) Subjective responses from occupants (existing buildings).

I.1 The design criteria used

The classification is made by showing a table with criteria used for energy calculations as shown in the example in Table I.1

Table I.1 — Classification based on criteria for energy calculations

Criteria of indoor environment	Category of this building	Design Criteria
Thermal conditions in winter	II	20-24 °C
Thermal conditions in summer	III	22-27 °C
Air quality indicator, CO_2	II	500 ppm above outdoor
Ventilation rate	II	1 l/sm^2
Lighting		E_m > 500 lx; UGR<19; 80<R_a
Acoustic environment		Indoor noise <35 dB(A) Noise from outdoors <55 dB(A)

people voting acceptable (thermal environment and air quality) is calculated for each of the representative spaces in the buildings. A weighted average according to the number of people in the different spaces are calculated and used for classification. More details can also be included by showing the distribution of votes on the 7-point thermal sensation scale and showing the percentage of people wanting higher, no change and lower room temperature.

The results can be shown in a table like the example in Table I.2.

Table I.2 — Examples of using the subjective reaction as classification of the indoor environment

Classification based on occupants responses	**Percentage**						
People finding the thermal environment acceptable	**85**						
People finding the indoor air quality acceptable	**80**						
Distribution on thermal sensation votes	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**
	0	**5**	**10**	**53**	**20**	**10**	**2**
Distribution of temperature preference	**Colder**		**Unchanged**		**Warmer**		
	20		**75**		**5**		

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