
**Energy performance of buildings —
Overall energy performance
assessment procedures —**

**Part 2:
Guideline for using indoor
environmental input parameters for
the design and assessment of energy
performance of buildings**

*Performance énergétique des bâtiments — Modes opératoires
d'évaluation de la performance énergétique globale —*

*Partie 2: Lignes directrices pour l'utilisation des paramètres d'entrée
de l'environnement intérieur pour la conception et l'évaluation de la
performance énergétique des bâtiments*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*.

Introduction

This document provides guidance to users in the application of ISO 17772-1 and gives additional background information. This document also describes and recommends additional topics related to the evaluation of the indoor environmental quality and new possibilities to improve the indoor environmental quality and reduce energy use of buildings like personalized systems, air cleaning technologies, consideration of adapted persons, etc.

This document explains how design criteria can be established and used for dimensioning of systems. It explains 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. This document also describes how gas phase air cleaning in the future can improve the indoor air quality and partly substitute for outside air. Finally, it identifies parameters to be used for monitoring and displaying of the indoor environment. Different categories of criteria can be used depending on type of building, type of occupants, type of climate and national differences. This document explains how these different categories of indoor environment can be individually selected as national criteria, be used in project agreement for design criteria and for displaying the yearly building performance in relation to indoor environmental quality. The designer can also define other categories using the principles from ISO 17772-1 and this document.

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Energy performance of buildings — Overall energy performance assessment procedures —

Part 2:

Guideline for using indoor environmental input parameters for the design and assessment of energy performance of buildings

1 Scope

This document deals with the indoor environmental parameters for thermal environment, indoor air quality, lighting and acoustic. It explains how to use ISO 17772-1 for specifying indoor environmental input parameters for building system design and energy performance calculations.

This document:

- specifies methods for long-term evaluation of the indoor environment obtained as a result of calculations or measurements;
- specifies criteria for measurements which can be used if required to measure compliance by inspection;
- identifies parameters to be used by monitoring and displaying the indoor environment in existing buildings.

This document is applicable 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. It explains how different categories of criteria for the indoor environment can be used.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 13731, *Ergonomics of the thermal environment — Vocabulary and symbols*

ISO 17772-1, *Energy performance of buildings — Indoor environmental quality — Part 1: Indoor environmental input parameters for the design and assessment of energy performance of buildings*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13731 and ISO 17772-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

4 Symbols and abbreviated terms

4.1 Symbols

For the purposes of this document, the symbols given in ISO 52000-1:2017, Annex C, and the following apply.

Symbol	Quantity	Unit
θ_o	indoor operative temperature	°C
θ_e	outdoor temperature	°C
θ_m	running mean outdoor air temperature	°C
θ_{ed-i}	daily mean outdoor temperature	°C
θ_o	operative temperature, design and energy calculations	°C
θ_{rm-i}	running mean outdoor temperature	°C
v_a	air speed (average/maximum)	m/s
θ_f	floor surface temperature	°C
ΔCO_2	concentration	ppm
$\Delta\theta_{pr}$	radiant temperature asymmetry	K
$\Delta\theta_a$	vertical air temperature difference	K
α	constant for running mean calculations	
q_{tot}	total ventilation rate	l/s
q_B	ventilation rate for building materials	l/s (m ²)
q_p	ventilation rate for persons	l/s (per person)
q_{tot}	total ventilation rate in occupied zone	l/s (m ²), l/s (person)
n	number of persons	
q_h	ventilation rate required for dilution of pollutant	L/s
G_h	generation of a pollutant	µg/s
C_h	guideline value of a pollutant	µg/L
$C_{h,i}$	guideline value of the substance	µg /m ³
$C_{h,o}$	supply concentration of a pollutant at air intake	µg/L
ε_v	ventilation effectiveness	—
A	floor area	m ²
$L_{p,A}$	A-weighted sound pressure level	dB(A)
$L_{eq, nT,A}$	equivalent continuous sound pressure level	dB(A)
D	daylight factor	
$DC_{a,j}$	daylight quotient of the Calculated area	j
E_m	average maintained illuminance	lx
M	activity level	met
I_{cl}	assumed clothing level winter/summer	clo

4.2 Abbreviated terms

ACH	air changers per hour
DR	draught rate, %
DSNA	daylight quotient sunscreen not activated
IEQ	indoor environmental quality
IEQ _{cat}	indoor environmental quality category for design

LPB ₁₋₃	low polluting building class
PD	percentage dissatisfied for local thermal discomfort
PMV	predicted mean vote
PPD	predicted percentage of dissatisfied, %
RH	relative humidity

5 Interactions with other standards and use of categories

This document interacts mainly with ISO 17772-1. This document explains how the indoor environmental criteria in ISO 17772-1 can be used 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 and cooling load calculations and sizing of the installed systems. Ventilation rates are used for sizing ventilation systems, 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 avoid possible negative effect of indoor environment and to give advice in respect of improvement of the energy efficiency of existing buildings as well as of the heating and cooling of buildings.

This document explains how values for the indoor environment (temperature, ventilation, lighting) are used as input to the calculation of the energy demand (building energy demand). Output from measured indoor environmental parameters in existing buildings (temperature, CO₂, ventilation rates, illumination levels) will enable the evaluation of overall annual performance and can be used to display the indoor environmental factors together with data for the energy performance.

Output from room temperature calculations and yearly dynamic building simulations will enable evaluation of the annual performance of buildings at the design stage.

This document describes methods for measurement of the indoor environment and for treating measured data related to the inspection of HVAC systems.

This document provides a method for categorization of indoor environment ([Clause 10](#)). This method can be used to integrate complex indoor environment information to simple classification for a possible indoor environment certificate.

6 How to establish design input criteria for dimensioning of buildings, heating, cooling, ventilation and lighting systems

6.1 General

Recommended input values are given for each of the different categories as shown in [Table 1](#). These categories can be used in different ways. First and foremost, they can be used to establish different levels of criteria for the design of buildings and building services. Different countries can standardize one category for design. The consultant and client of a building project can use the categories to agree on a specific design level. The intention is not that a building should be operated strictly in one class the whole year round. Instead the categories can be used to describe the yearly indoor environmental performance of a building by showing the distribution of the parameters in the different categories. It can then, on the national level or in a design/operation contract, be specified how much of the time the categories can be exceeded. This is shown in this document with some examples.

Table 1 — Categories of indoor environmental quality

Category	Level of expectation	Explanation
IEQ _I	High	Should be selected for occupants with special needs (children, elderly, handi-capped).
IEQ _{II}	Medium	The normal level used for design and operation.
IEQ _{III}	Moderate	Will still provide an acceptable environment. Some risk of reduced performance of the occupants.
IEQ _{IV}	Low	Should only be used for a short time of the year or in spaces with very short time of occupancy.

Even if a building is designed for category III, it can still be operated at a greater part of the year in category I or II. When the outdoor conditions are less severe (warmer in winter, colder in summer) than the design day, the capacity of the heating/cooling system will be large enough to keep the indoor environment within a narrower range.

It can be argued that selecting a higher category can increase the energy consumption. The energy requirement is, however, regulated by national building codes and cannot be exceeded. The challenge is then for the designer/operator of the building to obtain a high level of indoor environmental quality within the required energy criteria.

For design of buildings and dimensioning of room conditioning systems, the thermal comfort criteria (minimum room operative temperature in winter, maximum room operative temperature in summer) will be used as input for heating load and cooling load calculations. The design ventilation rates that are used for sizing the equipment are also used for energy calculations. The criteria are used as input values for the sizing and dimensioning of the systems as well as for design of buildings (facades, orientation, solar shading, etc.). Using a higher category will result in systems with a higher capacity; but depending on how the system is operated, the energy use is not necessarily higher. In the design a design external temperature for heating and a design day (including solar load) for cooling will normally be used.

To protect the designer/installer against complaint for not meeting the design intend, it is very important that the basis for design (boundary conditions, occupant density, etc.) are documented in the design documents. This will avoid discussions when these boundary conditions are changed during the lifetime of the building and the performance criteria cannot be met.

6.2 Thermal environment

6.2.1 General

Field studies in office buildings have shown that people’s expectations regarding the thermal environment can be different for buildings with installed mechanical cooling and buildings where the occupant only have the possibility to open windows to influence the thermal environment. Therefore, the design criteria are different for the two types of office buildings: mechanical heated and cooled buildings and buildings without mechanical cooling (see the definition in ISO 17772-1). The decision on which approach to use is taken by the client together with his consultant. It is possible for the consultant to show the difference between the two methods (acceptable indoor temperatures, energy use, etc.).

6.2.2 Mechanically heated and/or cooled buildings

Criteria for the thermal environment in heated and/or cooled buildings, in ISO 17772-1 are based on the thermal comfort indices Predicted Mean Vote-Predicted Percentage of Dissatisfied (PMV-PPD) with assumed typical levels of activity and typical values of thermal insulation for clothing (winter and summer) as described in detail in ISO 7730. Assuming different criteria for the PPD, different categories of the indoor environment are established. The PMV-PPD index considers the influence of all six thermal

parameters (clothing, activity, air temperature, mean radiant temperature, air velocity and humidity) and can be directly used as a criteria.

With a specified combination of activity and clothing, an assumed 50 % relative humidity and low air velocities (<0,1 m/s), the criteria can also be expressed as operative temperature as shown in [Annex B](#). For other air velocities and humidities, the corresponding operative temperature will be different. Some examples of recommended design indoor operative temperatures for heating and cooling, derived according to this principle, are presented in [Table B.2](#). This presents design values for the indoor operative temperature in buildings that have active heating systems in operation during winter season and active cooling systems during summer season, assumed clothing level for winter (1,0 clo) and summer (0,5 clo) and activity level (sedentary, 1,2 met). Note that the operative temperature limits should be adjusted when clothing levels and/or activity levels are different from the values mentioned in the table.

In some types of room, there can be a mixed type of occupants (sedentary-standing/walking) with different type of clothing (visitor to department store in outdoor clothing and shop assistance in indoor clothing). In these cases, a compromise should be found for the design criteria and the boundary conditions; this should be documented in the design documents and agreed by the client.

The temperatures in ISO 17772-1:2017, Table H.2) are operative temperatures (ISO 7726) with design loads at the design weather conditions which are specified nationally according to ISO 15927-4 and ISO 15927-5.

In most cases, the average room air temperature can be used as defining the design indoor temperature, but if temperatures of large room surfaces differ significantly from the air temperature (windows in winter and summer) or in situations where building occupants are often exposed to direct sun, the operative temperature should be used. Further information on clothing and activity can be found in ISO 9920 and ISO 8996. The value of design temperature can vary from the values shown, to take account of, for example, local custom (clothing) 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.

The design criteria in this subclause are both for design of buildings (dimensioning of windows, solar shading, building mass, etc.) and for design HVAC systems.

6.2.2.1 Local thermal discomfort

Criteria for local thermal discomfort (see ISO 17772-1), such as draught, radiant temperature asymmetry, vertical air temperature differences and floor surface temperatures, will also have an influence on the design of buildings and systems, and should be taken account of.

6.2.2.2 Personalized systems

Individual preferences regarding the indoor environment can be very different. Therefore, there is an increasing interest in using personalized systems for providing thermal comfort at individual workplaces. With personalized systems, it can be possible to satisfy all occupants. Recommended criteria for these types of systems are included in [Annex L](#).

6.2.3 Buildings without mechanical cooling

During the summer season and during the between-seasons (spring and autumn), the so-called adaptive criteria (upper and lower temperature limits that change with the running mean outside temperature) can be applied (see the category I, II and III upper and lower limits in ISO 17772-1:2017, Figure H.2). During the winter season, the same temperature limits should be applied as presented for buildings with mechanical cooling systems.

The adaptive criteria are based on data for office buildings, but could possibly be used for other buildings of similar type used mainly for human occupancy with mainly sedentary activities, where there is easy access to operable windows and occupants can freely adapt their clothing to the indoor

and/or external thermal conditions. This method only applies to spaces where occupants during the majority of their time have metabolic rates ranging from 1,0 met to 1,3 met. It is also important that strict clothing policies inside the building are avoided and that building occupants are free to adapt their clothing to indoor and/or external thermal conditions within a range of at least 0,4 clo to 1,0 clo.

The upper and lower limits presented in ISO 17772-1:2017, Figure H.2 only apply when the running mean external temperature is between 10 °C and 30 °C.

The temperature limits for the summer and the in-between-seasons only apply when the thermal conditions in the spaces at hand are regulated (during those seasons) primarily by the occupants through opening and closing of windows. Several field studies have shown that occupants' thermal responses in such spaces depend in part on the external climate, and differ from the thermal responses of occupants in buildings with mechanical cooling systems, mainly because of differences in thermal experience, presence of adaptive opportunities, differences in perceived control and shifts in occupants' expectations.

For this optional adaptive method to apply, the spaces in question should be equipped with operable windows or comparable facade components which open to the externals and which can be readily opened and adjusted by the occupants of the spaces. These operable windows (facade components) should be designed and positioned in such a way that on warmer days they allow occupants to fine tune the (wind pressure driven) air speeds inside.

There should be no mechanical cooling in operation in the space. Mechanical ventilation with unconditioned air (in summer) can be utilized, but opening and closing of windows should be of primary importance as a means of regulating thermal conditions in the space. In addition, occupants can have additional options for personal control over the indoor environment such as solar shading, fans, shutters, night ventilation, etc.

The spaces can 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.

In residential buildings, the opportunities for (behavioural) adaptation are relatively wide: one is relatively free to adjust metabolism and clothing insulation according to outside weather and momentary indoor temperatures. With an exception for bedrooms where the lower limit should be lower than in other rooms, studies have shown that operative temperature in bedrooms have a significant impact on sleep quality and general health.

Note that the field studies on the temperature limits shown in ISO 17772-1:2017, Annex H do not take work performance effects into account.

In landscaped (open plan) offices most occupants have only limited access to operable windows and therefore typically reduced personal control over natural ventilation, e.g. if there are workplaces placed in the middle of the room, away from direct access to operable windows. Therefore, the temperature limits established by this method will not always apply in such situations.

ISO 17772-1:2017, Figure H.1 includes three categories of temperature limits for use as outlined in the introduction and in ISO 17772-1:2017, Clause 5. The allowable indoor operative temperatures of Figure H.1 are plotted against the running mean external temperature θ_{rm} .

The following approximate [Formula \(1\)](#) can be used where records of daily mean external temperature are available:

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

The temperature limits presented in ISO 17772-1:2017, Figure H.1 should be used for the dimensioning of passive means to prevent overheating in summer conditions. Some examples are: dimensioning and orientation of windows, dimensioning of solar shading systems and of the thermal capacity of the building. Where the adaptive temperature limits presented in ISO 17772-1:2017, Figure H.1 (upper limits) cannot be guaranteed by passive means, then mechanical cooling should be used. In such

cases, the design criteria for buildings with mechanical cooling should be used (see summer limits in ISO 17772-1:2017, H.1).

Note that ISO 17772-1:2017, Figure H.1 already accounts for people's clothing adaptation, therefore, it is not necessary to estimate the clothing values when using the adaptive method presented in ISO 17772-1:2017, H.1. Also, it is normally not required that the following parameters be separately evaluated: local thermal discomfort, clothing insulation, metabolic rate, humidity and air speed.

6.2.4 Increased air velocity

Under summer comfort conditions with indoor operative temperatures >25 °C, increased air velocity can 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, or personally operable windows), the upper limits presented in ISO 17772-1:2017, Table H.2 and Figure H.1 can be increased by 2 K to 3 K. The exact temperature correction depends upon the air speed and can be derived from [Table B.3](#) and ISO 17772-1:2017, Table H.2 and Figure H.1. This method can also be used to overcome excessive temperatures in buildings if the local method for controlling air movement (fan, etc.) is available.

Considering the latter: if building occupants have access to fans, personal ventilation systems, personally operable windows, etc. that provide them with precise and step less control over air speed, the upper ISO 17772-1:2017, Table H.4 can be relaxed. The airspeed – temperature offset relation presented in the table is based upon heat transfer from the skin calculations.

The temperature correction by increased air velocity is assumed to be included in the adaptive method for free running buildings, as a prerequisite for this method is that occupants have access to operable windows under their personal control.

For buildings designed using the PMV-PPD approach, the temperature correction can be applied also if occupants have access to operable windows, and not only if the air velocity is provided from fans, etc.

6.3 Design for indoor air quality (ventilation rates)

6.3.1 General

6.3.1.1 Overview

The source control strategy together with ventilation (natural, mechanical and hybrid), placement of air intakes and filtration and air cleaning technologies contribute to improve the indoor air quality. The source control strategy is very important since air pollutants often are generated indoors. For residential buildings, indoor sources will often be the predominant source of air pollutants.

6.3.1.2 Source control

Source control should as often as possible be the primary strategy for controlling the level of air substances. In many cases, the sources will not be known, or little information about emission from building materials and furnishing are known or sources are brought into the space by occupants after the construction of the building. There are several national certification methods for materials that can be used for source control. A local exhaust of a high emitting source (kitchen hood, toilet exhaust, etc.) is also a type of source control.

6.3.1.3 Ventilation

The pollution remaining after source control is dealt with by dilution or displacement with appropriate ventilation air flow rates.

6.3.1.4 Time periods used for determining air flow rates

The methods described in this clause assume that pollutants emissions are constant in each time period considered and lead to a constant design ventilation air flow rate for each time period, therefore it can be a need to look at different time periods with constant values.

6.3.1.5 Building damage

Building damage can occur both at high indoor temperatures (very high room temperatures during warm summer days or if cooling is turned off) or too low temperature due to risk of condensation and resulting mould growth. Therefore, some heating, cooling and/or ventilation could also be needed outside the time of occupancy.

6.3.1.6 Design documentation

The design documents are very important to protect both the designer and the owner. During the lifetime of a building the use and loads can change. It is therefore essential that the original design criteria are documented.

6.3.2 Methods

6.3.2.1 General

6.3.2.1.1 Overview

ISO 17772-1 includes three methods for estimating the design air flow rates, which not necessarily will result in the same indoor air quality. The reason for including many methods is to be open for national preferences in choice of method. Again, it should be clearly stated in the design documents which method was used and why the method was chosen.

6.3.2.2 Method 1 based on perceived air quality

The perceived air quality is basically the odour level in the space perceived by the occupants. As odours will consist of emission from occupants (bio effluents) and emission from building materials and furnishing, [Formula \(2\)](#) is recommended:

$$q_{\text{tot}} = n \cdot q_p + A_R \cdot q_B \quad (2)$$

As we add the odours from people we also have to add the odour from other sources. The knowledge about the people component is relatively well-established[12][13][22][23], while the contribution from other sources is less well-documented. Because of differences in the building component (selection of indoor materials, etc.), the method includes three different building types (see [Annex D](#)).

Studies[25][26] have shown that people adapt to the odour from bio effluents, but very little to the emission from building materials and furnishing (reference). This does not mean that adapted persons are not subject to fatigue, impaired concentration, etc. that could follow after exposure to excessive concentration of bioeffluents in air over a longer time. However, the required minimum ventilation of 4 l/s per person apply also for adapted persons. In ISO 17772-1 the perceived air quality levels are set for non-adapted persons. If in special cases the design will be based on adapted persons information is included in [C.1](#).

6.3.2.3 Method 2 using criteria for individual substances

The ventilation rate required to dilute an individual substance (formaldehyde, other VOCs) can be calculated by a simple steady-state mass balance according to [Formula \(3\)](#):

$$Q_h = \frac{G_h}{C_{h,i} - C_{h,o}} \cdot \frac{1}{\epsilon_v} \quad (3)$$

NOTE Different units can be used in the formula (see ISO 17772-1). The ventilation effectiveness can be found from EN 16798-3 and EN 16798-4.

[Formula \(3\)](#) applies to steady-state conditions and the method requires that the external pollutant concentration is lower than the indoor. As indicator for human bioeffluents, the CO₂ concentration is often used. [C.3](#) shows examples calculations using CO₂ as an indicator.

6.3.2.4 Method 3 based on pre-defined ventilation air flow rates

An indirect method of expressing intended indoor air quality is to determine a certain minimum ventilation air flow rate estimated to meet requirement for perceived air quality and health in the occupied zone.

The pre-defined ventilation air flow rates can be expressed by a combination of one or more of the following components: total design ventilation for people and building components (q_{tot}); design ventilation per unit floor area (q_{m^2}); design ventilation per person (q_p); design air change rates (ACH); design opening areas (A_{tot}). Default values are presented in [Annex C](#).

6.3.3 Non-residential buildings

6.3.3.1 Applicable methods

Determining the design ventilation rate is the first step in the process of designing a ventilation system. The design ventilation air flow rates are used for designing any type of ventilation system, including mechanical, natural, hybrid ventilation systems.

6.3.3.2 Ventilation air flow rates during unoccupied periods

To avoid building damage (condensation, mould growth) and too high a level of pollutant concentrations at the start of the occupied hours, it can be necessary to have basic ventilation during unoccupied hours. It is appropriate to use a ventilation rate corresponding to the building component (pollution from the construction materials). Alternatively, full ventilation can be started at a given time before occupation, as described in [Annex C](#).

6.3.4 Residential buildings

6.3.4.1 General

In residential buildings, the occupants can, in most cases, be considered as adapted to the perceived air quality as they occupy the house for a longer time. Unlike other types of buildings, there is no need to maintain a situation where the indoor air quality is perceived as fresh by non-adapted persons entering the building, as this is an unusual situation for everyday use of the residential building. It is, of course, also possible to design the ventilation rate in residential buildings for non-adapted people. The main priority in residential buildings is to ensure a healthy indoor environment, and a secondary priority is to prevent damages to the building from excess of moisture.

6.3.4.2 Applicable methods

When dealing with ventilation rates, it should be taken into consideration that dwellings have scenarios, patterns of use and characteristics different from non-residential buildings (offices, schools, cinemas, bars or restaurants, etc.).

Concerning the scenarios, it is 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 television, 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 consider flexibility of use of different rooms: typically, e.g. bedrooms are scarcely occupied during daytime and occupied during night time, contrary to living rooms.

ISO 17772-1:2017, I.2 provides methods and details for a suitable design of ventilation systems in residential buildings. [C.2](#) explains further, with some examples, how to implement the methods proposed in ISO 17772-1 and how they impact on some types of ventilation systems available on the market.

6.3.4.3 Ventilation air flow rates during non-occupied periods

If the ventilation rate is lowered or stopped during unoccupied hours, it is recommended that the ventilation system starts before the building is occupied again or airing by window opening is done (see [C.4](#)).

6.3.5 Access to operable windows

To allow the building occupants to air their rooms and to provide contact to the outside, it is recommended to include operable windows. This applies to bedrooms and living rooms in dwellings and other buildings with rooms intended for sleeping, e.g. elderly homes. It also applies in offices, schools and child care facilities.

6.3.6 Filtration and air cleaning

To limit the indoor concentration and ingress of outdoor air pollutants, one or more of the following methods should be considered:

- placement of air intakes in less polluted areas of the building (e.g. towards courtyards instead of towards roads);
- filtration;
- air cleaning.

Design guidelines on air cleaning (filtration and gas phase) are given in ISO 17772-1 and ISO 16814. How to substitute outside air by air cleaning is described in [Annex M](#).

In order to choose appropriate air filtration and air cleaning solutions, ambient air quality at building location can be considered. When the building is in an area where the national standard or WHO guideline values for PM₁₀ or PM_{2,5} are exceeded, particle fine filters (plus a pre-filter when appropriate) evaluated according to EN 16798-3, or air cleaning devices can be provided to clean the external air at any location prior to its introduction to occupied spaces. It can also be possible for a limited time to close the outside air intakes and use recirculation combined with appropriate air cleaning.

When the building is in an area where the national standard/WHO guideline value for one or more gaseous contaminants is exceeded, such as ozone, NO_x, SO_x, PAH (poly aromatic hydrocarbons), gaseous filtration can be implemented as such or in combination with particle air filtration.

EN 16798-3 provides guidelines for filters performance and filters stage design according to the external air particles levels and the expected indoor air quality.

Air filters and air cleaning devices are selected and installed to protect ventilation system components and ducts from dust fouling as well. Dust fouling can reduce energy performance of heat exchanges of heating/cooling batteries and heat recovery systems. Note that humidity and temperature conditions combined with dust accumulation can lead to additional load by harmful substances of organic contaminants (microorganism's proliferation and their metabolites).

It is important to avoid that air filters themselves do not become a source of harmful or odorous substances. Regular maintenance, inspections and air filters change minimize the carryover of microorganism and keep supply air clean. EN 16798-3 and inspection standards provide recommendations and good practices for air filters maintenance and inspection.

6.4 Humidity

The humidity 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), special humidity requirements will exist. For buildings with no other humidity requirements than human occupancy (e.g. offices, schools and residential buildings), humidification is usually not needed and dehumidification is usually only needed in geographical areas with high outside humidity levels. Short-term exposure to very low or high values can be accepted.

6.5 Lighting

6.5.1 General

Windows are strongly favoured in buildings for the daylight they deliver and for the visual contact they provide with the outside environment. However, it is also important to ensure windows do not cause visual or thermal discomfort, or a loss of privacy.

Light is a necessary part to people's health and well-being. Light affects the mood, emotion and mental alertness of people. It can also support and adjust the circadian rhythms and influence people's physiological and psychological state.

For reasons of comfort and energy, in most cases, the use of daylight is preferred.

6.5.2 Non-residential buildings

The degree of visibility and comfort is wide ranging, and governed by activity type and duration of required lighting criteria for workplaces as specified in EN 12464-1 and for sports lighting in EN 12193. For some visual tasks in buildings and spaces, examples of required lighting criteria are presented in [Table E.1](#).

According to EN 12464-1:2011, 4.1, the main lighting requirements are determined by the satisfaction of three basic human needs: visual comfort, visual performance and visual safety.

To meet the illumination required in the rooms, buildings should have access to daylight to provide all or some of the illumination and during absence of daylight adequate amount of electric lighting should be installed to provide the required illumination. EN 15193-1 provides details about the effect of daylight on the lighting energy demand (monthly and annual basis) and daylight availability classification as a function of the daylight factor.

Too small windows might provide too little daylight, while too big unprotected windows might lead to overheating.

6.5.3 Residential buildings

Daylight in residential buildings can enter the space by façade and roof light openings or a combination of both. The contribution of daylight will vary in level, direction and spectral composition with time and provides variable modelling and luminance patterns, which is perceived as being beneficial for people in indoor environments. Good daylight provision depends on the size of the area lit by daylight compared to an area, which is not illuminated, by daylight.

6.6 Noise

The Equivalent Continuous Sound Level ($L_{eq,A}$) is the preferred single value parameter to describe noise. It is the constant sound pressure level which would produce the same sound energy, at a given point, over the same period of time T , as the considered variable sound pressure level.

$L_{eq,A}$ is a very good descriptor of noise due to sources active under operating conditions in a medium-long time span. It is widely used as descriptor of equipment noise in continuous operation (e.g. ventilation, air conditioning, etc.) in most of the regulations and national standards.

To adequately assess a noise with respect to requirements, it is necessary to normalize the equivalent continuous level with respect to reverberation time ($L_{eq,nT,A}$) to take into account the sound absorption of the room. $L_{eq,nT,A}$ is defined in ISO 16032 and ISO 10052.

ISO 17772-1 is provided for design and assessment of energy efficiency of buildings, therefore, with respect to noise, only HVAC systems are fully relevant. Nevertheless, these systems are usually strictly connected to plumbing, and the contribution of these has to be considered to better achieve comfort conditions. Moreover, other sources of noise are important for a comfortable use of the buildings such as lifts and motorized systems for opening doors, gates and similar and should be taken into account in the design of buildings. The use of L_{max} (FAST) instead of L_{max} (SLOW) allow to better include the effect of impulsive phenomena and description of discontinuous noise source functioning (see ISO 16032). Some values of acceptable noise from the most common service equipment in buildings are given in [Annex L](#).

7 Indoor environment parameters for energy calculation

7.1 General

The input values for energy calculations are based on the same concepts as the criteria for design. The criteria presented in ISO 17772-1 are then also reflected in the occupant schedules.

7.2 Thermal environment

7.2.1 General

As the energy calculations can be performed on seasonal, monthly or hourly basis (dynamic simulation), the indoor environment is specified accordingly.

7.2.2 Seasonal and monthly calculations

During the between-seasons (with θ_{rm} between around 10 °C and 15 °C), adjusted upper and lower temperature limits that lie in between the winter and summer values mentioned in [Table B.2](#) can be used.

7.2.3 Hourly calculations or dynamic building simulation

The indoor temperatures can be calculated by dynamic building simulations. Recommended values for the acceptable range of the indoor temperature for heating and cooling are presented in ISO 17772-1:2017, Annex H. The midpoint of the temperature range should be used as a target value but the indoor temperature can 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 can be estimated using one of the methods described in [Clause 8](#).

Assumptions related to allowable exceedance is described in [Clause 8](#).

7.3 Indoor air quality and ventilation

7.3.1 General

An acceptable level of ventilation is required in both non-residential and residential buildings to achieve good indoor air quality.

7.3.2 Non-residential buildings

The recommended ventilation rates for energy calculations are basically the same as used for design of systems. In systems with variable air flow control and demand controlled ventilation, the ventilation rate can vary between maximum, for full occupancy, and minimum, when the considered space is unoccupied. In case of CO₂-controlled ventilation, the CO₂-concentration values in ISO 17772-1:2017, Annex I can be used. Further recommended values for the excess of CO₂ concentration above outdoors CO₂ concentration are listed in [Annex C](#).

7.3.3 Residential buildings

The concept of design ventilation rates and the use of demand controlled ventilation are similar to offices (see [7.3.2](#)).

7.4 Humidity

The same criteria used for design are also used for energy calculations.

7.5 Lighting

The same criteria used for design are also used for energy calculations.

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 might 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 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 is based on the following activities: design ([8.2](#)), calculations ([8.3](#)), measurements ([8.4](#)), or 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:

- a) thermal criteria for winter: specified design values for indoor temperature during heating are in [6.2.2](#);
- b) thermal criteria for summer: specified design values for indoor temperatures during cooling are in [6.2.2](#) and [6.2.3](#);

- c) air quality and ventilation criteria: design values for ventilation are in [6.3.3](#) for non-residential buildings, and in [6.3.4](#) for residential buildings;
- d) humidity criteria: design values for humidity are in [6.4](#);
- e) lighting criteria: design values for lighting are in [6.5](#);
- f) noise criteria: design values for noise are given in [6.6](#).

8.3 Calculated indicators of indoor environment

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

8.3.1 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.

8.3.2 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 the percentage of time when the criteria is met or not.

This procedure is described with an example in [Annex H](#).

8.3.3 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 H](#).

8.3.4 Overall thermal comfort criteria (weighted PMV criteria)

This procedure is described with an example in [Annex H](#).

8.4 Measured indicators

8.4.1 General

Deviations from the selected criteria should be allowed. Some national criteria express “acceptable deviations” as an acceptable number of hours or percentage of occupancy time outside the criteria based on a yearly evaluation (e.g. 100 h to 150 h assuming 2 000 occupancy hours; or 3 % of the occupancy time). This can also be given as weighted hours, where the level of deviation is also taken into account.

If no national criteria for deviations are available, the recommended criteria in [Annex I](#) can be used. These criteria can be given on a weekly, monthly and yearly basis.

The weather data file used in the building simulation to design the performance of the ventilation system might differ from the actual weather data. A heat wave might influence on the actual performance of the building and cause, for example, overheating. In this matter, a longer period of time where the building is outside the designed category can occur.

8.4.2 Thermal environment

The measurements should 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 should fulfil the requirements in ISO 7726.

8.4.3 Indoor air quality and ventilation

8.4.3.1 General

Indoor air quality and ventilation of building is evaluated with representative samples taken from different zones of the building.

8.4.3.2 Ventilation method

Ventilation of buildings can be evaluated by measuring air flows in ducts or by tracer gas measurements or by using, for example, CO₂ as an indicator.

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 CO₂ 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 at the exhaust air.

8.4.4 Lighting

Lighting quality is evaluated by measurements of illuminances on task areas, on surrounding areas and on walls and ceiling. Illuminance uniformity should be greater or equal than the recommended values reported in EN 12464-1 for each kind of surface. The verification procedure in of EN 12464-1:2011, Clause 6 can be followed.

The main parameters determining the luminous environment with respect to electric light and daylight are:

- luminance distribution;
- illuminance;
- uniformity of illuminance;
- glare;
- daylight factor;
- directionality of light;
- lighting in the interior space;
- variability of light (levels and colour of light);
- colour rendering and colour appearance of the light;
- flicker.

8.4.5 Noise

Noise is evaluated with a representative sample from rooms and spaces served by 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 service equipment would violate the noise criteria (unless special measures are taken, e.g. intelligent placement or sound attenuation of air intakes) or the user control of the system. Also in the case of mechanical ventilation and cooling, providing the required amount of air could 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 external noise from outside service equipment) should be used to evaluate the noise. The criteria for noise are given in [Annex F](#).

This statement of ISO 17772-1 assumes knowledge in the design phase of the actual level of external noise. These data are often not available or can be influenced by the presence of the building itself. It can be difficult to fix design values when the noise level is dependent not only on the operating conditions of the equipment. Many national regulations define criteria for the evaluation of external noise and depend on considerations related to the local use.

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 can be used. In [Annex J](#), recommended procedures and questionnaires are given for the systematic registration of subjective reactions of building occupants.

9 Inspections and measurement of the indoor environment in existing buildings

It is often 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.

Requirements for inspection can be found at national level or in the standards; see also EN 15378:2017, 6.2.

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

9.1 Measurements

9.1.1 General

In existing buildings, measurements should be used to check whether the performance of the building and its building service systems (ventilation system, heating and cooling devices, artificial lighting) meets the design requirements. [9.1.2](#) and [9.1.3](#) indicate how such measurements can be conducted for each indoor environmental quality parameter.

9.1.2 Thermal environment

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

The recommendations given in ISO 7726 should be followed as far as the location of measurement instrumentation within the spaces is concerned.

Measurements should be made where occupants are known to spend most of their time and under representative weather conditions of the cold and warm season; for the winter (heating season), measurements at or below mean outside temperatures for the three coldest months of the year, and for the summer (cooling season), measurements at or above statistic average outside temperatures for the three 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 (ISO 7726).

9.1.3 Indoor air quality

Indoor air quality measurements are usually based on the indirect approach of measuring ventilation rates. However, indoor air quality depends as well on the presence of specific indoor pollutants that can degrade occupants' perception of indoor air quality or impair occupants' health (e.g. smell, sick building symptoms) or both. Ventilation measurements should show that the requirements for fresh air supply are met. In addition, investigation and measurements of specific pollutants (e.g. formaldehyde, other VOC, fine dust PM₁₀ or PM_{2,5}) will be needed to identify levels, potential sources (indoor or outdoor) and strategies to be implemented for remediation such as:

- indoor air pollutant source emission control and reduction;
- ventilation to dilute air pollutant concentrations;
- outdoor air filtration at mechanical ventilation inlets;
- additional pollutant specific air cleaning.

[Annex I](#) provides as reference WHO guidelines values for indoor and outdoor air pollutants.

How this should be done is outside the scope of this document.

An exception is the measurement of CO₂: in buildings where people are the main pollution sources, the ventilation rates (per person or per m²) can be estimated using CO₂ measurement. The decay of CO₂ when people are leaving a building can be used to measure the ventilation rate. Measurements should be made where occupants are known to spend most of their time, preferably at head level during typical high load conditions.

CO₂ 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 representative rooms might be enough.

If the design is based on specified amount of outside air supply, this amount should be confirmed by measurement at room level. A direct measurement in the supply duct or at the supply grill is often more practical and precise than the measurement of CO₂ concentrations.

First, the total fresh air supply for the whole building should be measured and translated into an average per m² value. Also in a (representatively selected) sample of rooms the fresh air supply 'at room level' should be measured. The latter should be translated in both a fresh air supply per m² and a fresh air supply per person value, considering actual occupancy levels and design occupancy levels.

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

9.1.4 Indoor light quality measurements based on illuminance

Illuminances should be measured both on task areas and on surrounding areas to conform to values recommended in EN 12464-1 at all operational times. Other parameters as UGR, Ra, etc. can be checked, according to EN 12464-1.

Illuminance levels measurements of artificial lighting are carried out without the presence of daylight. Preferably measurements of daylight should be carried out during an average cloudy day.

The maintained illuminance values should be measured on the horizontal plane in the occupational zone at approximately 0,8 m for regular occupied spaces and at 0,1 m in circulation areas and sports halls.

Measurement should be carried out 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, so that the total performance of building can be evaluated. For this certificate, the classification of indoor environment is necessary. For the certification, it can 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 only based on 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, and (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 K](#).

10.3 Recommended overall evaluation of the indoor environment and certification

For the overall evaluation, it is recommended that a comfort “footprint” 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 CO₂ concentrations) are within the different categories (I, II, III, and IV). Examples are included in [Annex K](#).

Annex A (informative)

Information about national annexes

The intention of Annexes A to G is described clearly in ISO 17772-1. On a national level, it can be decided if different categories should be used or only one category for the indoor environment is described. It is recommended to define one category for design and energy calculation. Then more categories can be used to describe the yearly quality of the indoor environment.

This annex provides a reminder that ISO 17772-1:2017, Annexes A to G give empty tables suitable for national implementation of that document, if values different from those shown in ISO 17772-1:2017, Annexes H to N are considered more appropriate.

Explanations and discussions on the relevant items of ISO 17772-1:2017, Annexes A to G are given in [Annexes A to G](#).

Annex A can be used to provide additional national comments to ISO 17772-1:2017, Annexes A to G.

Annex B (informative)

Recommended criteria for the thermal environment

B.1 Recommended categories for design of mechanically heated and cooled buildings

The following paragraphs give some more explanations to the recommended criteria in ISO 17772-1.

Table B.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	<25	$-1,0 < PMV < +1,0$

Table B.2 — Examples of recommended design values of the indoor operative temperature in winter and summer for buildings with mechanical cooling systems

Type of building/space	Category	Operative temperature, °C	
		Minimum for heating (winter season), approximately 1,0 clo	Maximum for cooling (summer season), approximately 0,5 clo
Residential buildings: living spaces (bedrooms, drawing rooms, kitchens, etc.) Sedentary approximately 1,2 met	I	21,0	25,5
	II	20,0	26,0
	III	18,0	27,0
	IV	16	28
Single office (cellular office) Sedentary approximately 1,2 met	I	21,0	25,5
	II	20,0	26,0
	III	19,0	27,0
	IV	17	28
Landscaped office (open plan office) Sedentary approximately 1,2 met	I	21,0	25,5
	II	20,0	26,0
	III	19,0	27,0
Conference room Sedentary approximately 1,2 met	I	21,0	25,5
	II	20,0	26,0
	III	19,0	27,0
	IV	17	28

NOTE During the between seasons (with θ_{rm} between 10 °C and 15 °C), temperature limits that lie in between the winter and summer values can be used.

Table B.2 (continued)

Type of building/space	Category	Operative temperature, °C	
		Minimum for heating (winter season), approximately 1,0 clo	Maximum for cooling (summer season), approximately 0,5 clo
Auditorium Sedentary approximately 1,2 met	I	21,0	25,5
	II	20,0	26,0
	III	19,0	27,0
Cafeteria/restaurant Sedentary approximately 1,2 met	I	21,0	25,5
	II	20,0	26,0
	III	19,0	27,0
	IV	17	28
Classroom Sedentary approximately 1,2 met	I	21,0	25,0
	II	20,0	26,0
	III	19,0	27,0
	IV	17	28
Kindergarten Seated-standing approximately 1,2 met	I	21,0	25,0
	II	20,0	26,0
	III	19,0	27,0
	IV	Not recommended	
Department store Standing-walking approximately 1,6 met	I	17,5	24,0
	II	16,0	25,0
	III	15,0	26,0
	IV		

NOTE During the between seasons (with θ_{rm} between 10 °C and 15 °C), temperature limits that lie in between the winter and summer values can be used.

It can be difficult to set recommended values for kindergartens and department stores. In both building types, there stay occupants with different clothing and activity level. So, one set of criteria will not be applicable to all occupants.

Local thermal discomfort

The maximum allowable mean air velocity is a function of local air temperature and turbulence intensity. The turbulence intensity can vary between 30 % and 60 % in spaces with mixed flow air distribution. In spaces with displacement ventilation or without mechanical ventilation, the turbulence intensity can be lower. Draught problems could be due to high air velocities from opening of windows, ventilation and air conditioning systems, but it can also be due to cold down draught from cold vertical surfaces.

Draught is an unwanted local cooling of the body caused by air movement. The discomfort due to draught can be expressed as the percentage of people predicted to be bothered by draught. The draught rating (DR) can be calculated by the following [Formula \(B.1\)](#) (model of draught):

$$DR = (34 - t_{a,l}) (v_{a,l} - 0,05)^{0,62} (0,37 \cdot v_{a,l} \cdot T_u + 3,14) \quad (\text{B.1})$$

For $v_a < 0,05 \text{ ms}^{-1}$ insert $v_a = 0,05 \text{ ms}^{-1}$

For $DR > 100 \%$ use $DR = 100 \%$

where

- DR is the draught rating, i.e. the percentage of people dissatisfied due to draught;
- $t_{a,l}$ is local air temperature, in degrees Celsius, 20 °C to 26 °C;
- $v_{a,l}$ is the local mean air velocity in meters per second, <0,5 ms⁻¹;
- T_u is the local turbulence intensity (%) defined as the ratio of the standard deviation of the local air velocity to the local mean air velocity, 10 % to 60 %.

The model applies to people at light, mainly sedentary activity with a thermal sensation for the whole body close to neutral and for prediction of draught at the neck. At arms and feet level, the model can overestimate the predicted draught rating. The sensation of draught is lower at activities higher than sedentary (>1,2 met) and for people feeling warmer than neutral.

Vertical air temperature difference

A high vertical air temperature difference between head and ankles can cause discomfort. These limits are important when designing displacement ventilation system.

Warm and cool floors

If the floor is too warm or too cool, the occupants will feel uncomfortable due to warm or cool feet. For people wearing light indoor shoes, it is the temperature of the floor rather than the material of the floor covering which is important for the comfort. For longer occupancy, the criteria are not valid for electrically heated floors. By electrical heating, a certain heat input is provided independent of the surface temperature. A water-based heating system will not produce temperatures higher than the water temperature.

For spaces which people occupy with bare feet, see ISO/TS 13732-2.

Radiant asymmetry

Radiant asymmetry can also cause discomfort. People are most sensitive to radiant asymmetry caused by warm ceilings or cool walls (windows).

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

ISO 17772-1:2017, Figure H.1 recommended indoor operative temperatures (θ_0) are presented for buildings without mechanical cooling systems, according to the definition and calculation of external running mean temperature (θ_{rm}) as described in ISO 17772-1:2017, 6.2.2.

A few remarks related to Figure H.1:

- in winter with external running mean temperatures below 10 °C the standard heating season criteria, as presented in [Table H.1](#), should be used;
- the operative temperature limits as presented in the figure only apply when 10 °C < θ_{rm} < 30 °C above $\theta_{rm} = 25$ °C the limits are based on limited field data;
- there is no mechanical cooling system installed: mechanical ventilation with unconditioned air (in summer) can be utilized, but opening and closing of windows should be of primary importance as a means of regulating thermal conditions in the space. In addition, occupants can have additional options for personal control over the indoor environment such as solar shading, fans, shutters, night ventilation, etc.

How to use the adaptive criteria in practice?

Like with the non-adaptive criteria described in [B.1](#), the adaptive criteria can be used during the (re) design stage [of buildings (building facades) and their HVAC systems], or when deciding about building operation (set-points) or when evaluating the indoor climate in existing buildings. For standard buildings, normally category II limits are recommended to be used as design criteria. Only there were sensitive individuals are expected to be positioned (think e.g. of seating positions for the elderly) the stricter category I limits can be used.

When the adaptive criteria are used as part of a design standard for naturally conditioned spaces, it is recommended to use a building simulation tool with an 'adaptive module' to predict what the indoor conditions will be. The output of that simulation (e.g. hourly operational temperature values) then can be compared with the maximum operative temperatures allowed under the adaptive approach in order to decide whether conditions will be acceptable or not. Simulation outcomes should be presented in terms of percentage of operating time (e.g. weekdays from 8,00 h to 18,00 h) that the operative temperature is within the category I limits, between the category I and the category II limits, between the category II and the category III limits and outside the category III limits. When the simulation shows that operative temperatures are a substantial amount of time above the adaptive comfort limits that were selected beforehand than design modifications (e.g. of the façade or the thermal mass) should be made. After which, the simulation process is repeated. When the design modifications are not sufficient to meet the adaptive criteria, one might consider introducing an active cooling systems. Which implies that one should switch to the non-adaptive upper limits for the operative temperature as described in [B.1](#).

The adaptive comfort criteria too can be used in the context of building and building service system operation. For example, when determining set-points for automated façade systems (with operable parts) or when fine tuning summer night cooling settings of mechanical ventilation systems.

A third way to use the adaptive criteria is in the context of building performance checks. This can be on a regular basis in the context of general contract requirements or as part of an indoor climate survey that was started due to thermal comfort complaints. Acceptability of existing thermal conditions in buildings without active cooling systems (and with operable windows) can be evaluated with the adaptive criteria as reference. In older buildings, the category III temperature limits should be used as a baseline, in newer buildings (less than 10 years old) in most cases, the category II limits should be used. Measurement outcomes should be presented in terms of percentage of operating time (e.g. weekdays from 8,00 h to 18,00 h) that the operative temperature is within the category I limits, between the category I and the category II limits, between the category II and the category III limits and outside the category III limits. Measurement duration is at least a week, preferably around 3 weeks. Measurements should be done both under (typical) summer and under typical (winter) conditions.

If operative temperatures are above 25 °C and special equipment (e.g. table fans, ceiling fans or personal ventilation systems with a boost function) is installed that allows building occupants to create elevated air speeds at their work stations, it can be permitted to increase the upper temperature limits as presented in ISO 17772-1:2017, Figure H.1 with a delta T_o as presented in [Table B.3](#).

Table B.3 — Indoor operative temperature correction ($\Delta\theta_o$)

Average air speed (v_a) 0,6 m/s	Average air speed (v_a) 0,9 m/s	Average air speed (v_a) 1,2 m/s
1,2 K	1,8 K	2,2 K

B.3 Recommended indoor temperatures for energy calculations

Table B.4 — 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-rooms living rooms, kitchens, etc.) Sedentary activity ~1,2 met	I	21,0 to 25,0	23,5 to 25,5
	II	20,0 to 25,0	23,0 to 26,0
	III	18,0 to 25,0	22,0 to 27,0
	IV	17,0 to 25,0	21,0 to 28,0
Offices and spaces with similar activity (single offices, open plan offices, conference rooms, auditorium, cafeteria, restaurants, classrooms) Sedentary activity ~1,2 met	I	21,0 to 23,0	23,5 to 25,5
	II	20,0 to 24,0	23,0 to 26,0
	III	19,0 to 25,0	22,0 to 27,0
	IV	17,0 to 26,0	21,0 to 28,0
Kindergarten Seated-standing- activity ~1,2 met	I	21,0 to 23,0	23,5 to 25,5
	II	20,0 to 24,0	23,0 to 26,0
	III	19,0 to 25,0	22,0 to 27,0
Department store Standing-walking activity ~1,6 met	I	17,5 to 20,5	22,0 to 24,0
	II	16,0 to 22,0	21,0 to 25,0
	III	15,0 to 23,0	20,0 to 26,0

As noted in [B.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 C (informative)

Basis for the criteria for indoor air quality and ventilation rates

C.1 Default design ventilation air flow rates for non-residential buildings

C.1.1 General

There does not exist a common standard index for the indoor air quality. The indoor air quality is therefore expressed as the required level of ventilation or CO₂ concentrations. It is generally accepted that the indoor air quality is influenced by emission from people and their activities (bio effluents, cooking), 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 (perceived air quality). Health effects can be attributed to specific components of emission and if the concentration of one source is reduced the concentration of others will also be reduced. Comfort is more related to the perceived air quality (odour, irritation). In these cases, different sources of emission can have an odour component that adds to the odour level. There is however no general agreement on how different sources of emission should be added together. In the present standard, the criteria will in the following be expressed in different ways:

- method based on perceived air quality;
- method using limit values of gas concentration;
- method based on predefined ventilation flow rates.

For CO₂ and temperature controlled systems, the ventilation requirement is fulfilled if the limits for CO₂ and temperature are fulfilled.

Infiltration can be calculated as a part of the ventilation air flow rate.

C.1.2 Method 1: Method based on perceived air quality

The calculated design ventilation rate is from two components:

- values from ISO 17772-1;2017, Table I.1 concerning ventilation for pollution from the occupants (bio effluents);
- values from ISO 17772-1;2017, Table I.2 concerning ventilation for the pollution from the building and systems.

The ventilation for each category is the sum of these two components as illustrated with [Formula \(1\)](#).

The ventilation rates for occupants can be based on either adapted or non-adapted building occupants. It can be a reasonable approach to design specific room types for adapted persons, e.g. auditoriums, cinemas, classrooms. To use design for adapted persons in these types of rooms will require an airing or strong ventilation between sessions. It is also reasonable to use adapted persons in residential buildings. People only adapt to the bio effluents (odour) and the corresponding values for non-adapted and adapted occupants (q_p) are listed in [Table C.1](#). With these lower ventilation rates, the occupants could still feel an acceptable perceived air quality, but it can decrease the performance or learning efficiency of the occupants (schools, auditoriums).

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

Category	Expected percentage of dissatisfied	Airflow per non-adapted person l/s/person	Airflow per adapted person l/s/person
I	15	10	3,5
II	20	7	2,5
III	30	4	1,5
IV	40	2,5	1,0

ISO 17772-1 recommends a minimum of 4 l/s per person of total ventilation. The value is based on a European study Ventilation and Health and was recommended where the major contributor to the emission would be people.

The ventilation rates (q_B) for the building emissions are calculated according to ISO 17772-1:2017, Table I.2.

Total ventilation rate for a room is calculated from ISO 17772-1:2017, Formula (1).

Examples of the total ventilation rates for non-industrial and non-residential buildings based on these values, calculated using ISO 17772-1:2017, Formula (I.1) with default occupancy densities, are given in [Table C.2](#) (for non-adapted persons) and [Table C.3](#) (for adapted persons). 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 (see ISO 17772-1).

The total ventilation rate can either be given as l/(s m²) or as l/s/person as shown in [Tables C.2](#) and [C.3](#).

A building is, by default, a low-polluting building unless prior activity has resulted in pollution of the building (e.g. smoking). In this case, the building is regarded as non-low polluting. The category very low-polluting requires that the majority of building materials used for finishing the interior surfaces meet the national or international criteria of very low-polluting materials. An example of how to define very low-polluting building materials is given in [Annex D](#).

Table C.2 — Non-adapted persons — Examples of recommended ventilation rates for non-residential buildings with default occupancy density for three categories of pollution from the buildings itself

Type of building or space	Category	Floor area m ² /person	q_p		q_B	q_{tot}			q_B	q_{tot}		q_B	q_{tot}	
			Minimum ventilation rate											
			l/(s m ²)	l/s pers.	l/s, m ²	l/s, m ²	l/s,pers	l/s, m ²	l/s, m ²	l/s,pers	l/s, m ²	l/s, m ²	l/s,pers	
Single office	I	10	1	10	0,5	1,5	15	1	2,0	20,0	2	3,0	30	
	II	10	0,7	7	0,35	1,1	11	0,7	1,4	14,0	1,4	2,1	21	
	III	10	0,4	4	0,2	0,6	6	0,4	0,8	8,0	0,8	1,2	12	
	IV	10	0,25	2,5	0,15	0,4	4	0,3	0,6	5,5	0,6	0,9	9	
Landscape office	I	15	0,7	10	0,5	1,2	18	1	1,7	25,0	2	2,7	40	
	II	15	0,5	7	0,35	0,8	12	0,7	1,2	17,5	1,4	1,9	28	
	III	15	0,3	4	0,2	0,5	7	0,4	0,7	10,0	0,8	1,1	16	
	IV	15	0,2	2,5	0,15	0,3	5	0,3	0,5	7,0	0,6	0,8	12	

NOTE Italics is for situations where the calculated ventilation rate is lower than 4 l/s per person required for health.

Table C.2 (continued)

Type of building or space	Category	Floor area m ² /person	q _p		q _B	q _{tot}			q _B	q _{tot}			q _B	q _{tot}	
			Minimum ventilation rate			l/s, m ²	l/s, m ²	l/s, pers		l/s, m ²	l/s, m ²	l/s, pers		l/s, m ²	l/s, m ²
			l/(s m ²)	l/s pers.	For occupancy only				For very low-polluted building				For low-polluted building		
Conference room	I	2	5	10	0,5	5,5	11	1	6,0	12,0	2	7,0	14		
	II	2	3,5	7	0,35	3,9	8	0,7	4,2	8,4	1,4	4,9	10		
	III	2	2	4	0,2	2,2	4	0,4	2,4	4,8	0,8	2,8	6		
	IV	2	1,25	2,5	0,15	<i>(1,4) 1,8</i>	<i>(3) 4</i>	0,3	<i>(1,6) 2</i>	<i>(3,1) 4</i>	0,6	1,9	4		
Auditorium	I	0,75	13,3	10	0,5	13,8	10	1	14,3	10,8	2	15,3	12		
	II	0,75	9,3	7	0,35	9,7	7	0,7	10,0	7,5	1,4	10,7	8		
	III	0,75	5,3	4	0,2	5,5	4	0,4	5,7	4,3	0,8	6,1	5		
	IV	0,75	3,3	2,5	0,15	<i>(3,5) 4,7</i>	<i>(3) 4</i>	0,3	<i>(3,6) 5,3</i>	<i>(2,7) 4</i>	0,6	<i>(3,9) 4,7</i>	<i>(3) 4</i>		
Restaurant	I	1,5	6,7	10	0,5	7,2	11	1	7,7	11,5	2	8,7	13		
	II	1,5	4,7	7	0,35	5,0	8	0,7	5,4	8,1	1,4	6,1	9		
	III	1,5	2,7	4	0,2	2,9	4	0,4	3,1	4,6	0,8	3,5	5		
	IV	1,5	1,7	2,5	0,15	<i>(1,8) 2,4</i>	<i>(3) 4</i>	0,3	<i>(2,0) 2,7</i>	<i>(3,0) 4</i>	0,6	<i>(2,3) 2,4</i>	<i>(3) 4</i>		
Classroom	I	2	5	10	0,5	5,5	11	1	6,0	12,0	2	7,0	14		
	II	2	3,5	7	0,35	3,9	8	0,7	4,2	8,4	1,4	4,9	10		
	III	2	2	4	0,2	2,2	4	0,4	2,4	4,8	0,8	2,8	6		
	IV	2	1,25	2,5	0,15	<i>(1,4) 1,8</i>	<i>(3) 4</i>	0,3	<i>(1,6) 2</i>	<i>(3,1) 4</i>	0,6	1,9	4		
Kindergarten	I	2	5	10	0,5	5,5	11	1	6,0	12,0	2	7,0	14		
	II	2	3,5	7	0,35	3,9	8	0,7	4,2	8,4	1,4	4,9	10		
	III	2	2	4	0,2	2,2	4	0,4	2,4	4,8	0,8	2,8	6		
	IV	2	1,25	2,5	0,15	<i>(1,4) 1,8</i>	<i>(3) 4</i>	0,3	<i>(1,6) 2</i>	<i>(3,1) 4</i>	0,6	1,9	4		
Department store	I	7	1,4	10	1	2,4	17	2	3,4	24	3	4,4	31		
	II	7	1,0	7	0,7	1,7	12	1,4	2,4	16,8	2,1	3,1	22		
	III	7	0,6	4	0,4	1,0	5	0,8	1,4	9,6	1,2	1,8	12		
	IV	7	0,4	2,5	0,3	0,7	7	0,6	1,0	6,7	0,9	1,3	9		

NOTE Italics is for situations where the calculated ventilation rate is lower than 4 l/s per person required for health.

Table C.3 — Adapted persons. Examples of recommended ventilation rates for non-residential buildings with default occupant density for three categories of pollution from building itself

Type of building or space	Category	Floor area m ² /person	q _p		q _B	q _{tot}			q _B	q _{tot}			q _B	q _{tot}	
			Adapted q _p according to Table B			l/s, m ²	l/s, m ²	l/s, person		l/s, m ²	l/s, m ²	l/s, person		l/s, m ²	l/s, m ²
			l/s, m ²	l/s, person	For very low-polluted building				For low-polluted building				For non-low polluted building		
Conference room	I	2	1,75	3,5	0,5	2,25	4,5	1	2,75	5,5	2	3,75	7,5		
	II	2	1,25	2,5	0,35	<i>1,60</i>	<i>(3,2)4</i>	0,7	<i>1,95</i>	<i>(3,9)4</i>	1,4	2,65	5,3		
	III	2	0,75	1,5	0,3	<i>1,05</i>	<i>(2,1)4</i>	0,4	<i>1,15</i>	<i>(2,3)4</i>	0,8	<i>1,55</i>	<i>(3,1)4</i>		
	IV	2	0,50	1	0,25	<i>0,75</i>	<i>(1,5)4</i>	0,3	<i>0,80</i>	<i>(1,6)4</i>	0,6	<i>1,10</i>	<i>(2,2)4</i>		

NOTE Values in italics indicate situations where the calculated ventilation rate is lower than the minimum value of 4l/s per person required for health. The values are expressed per m² floor area even if the emitting surfaces can be floor, wall, etc.

Table C.3 (continued)

Type of building or space	Category	Floor area m ² /person	q _p		q _B	q _{tot}		q _B	q _{tot}		q _B	q _{tot}	
			Adapted q _p according to Table B			l/s, m ²	l/s, person		l/s, m ²	l/s, person		l/s, m ²	l/s, person
			l/s, m ²	l/s, person	For very low-polluted building			For low-polluted building			For non-low polluted building		
			For occupancy										
Auditorium	I	0,75	4,67	3,5	0,5	5,17	(3,9)4	1	5,67	4,3	2	6,67	5,0
	II	0,75	3,33	2,5	0,35	3,68	(2,8)4	0,7	4,03	(3,0)4	1,4	4,73	(3,6)4
	III	0,75	2,00	1,5	0,3	2,30	(1,7)4	0,4	2,40	(1,8)4	0,8	2,80	(2,1)4
	IV	0,75	1,33	1	0,25	1,58	(1,2)4	0,3	1,63	(1,2)4	0,6	1,93	(1,5)4
Classroom	I	2	1,75	3,5	0,5	2,25	4,5	1	2,75	5,5	2	3,75	7,5
	II	2	1,25	2,5	0,35	1,60	(3,2)4	0,7	1,95	(3,9)4	1,4	2,65	5,3
	III	2	0,75	1,5	0,3	1,05	(2,1)4	0,4	1,15	(2,3)4	0,8	1,55	(3,1)4
	IV	2	0,50	1	0,25	0,75	(1,5)4	0,3	0,80	(1,6)4	0,6	1,10	(2,2)4

NOTE Values in italics indicate situations where the calculated ventilation rate is lower than the minimum value of 4 l/s per person required for health. The values are expressed per m² floor area even if the emitting surfaces can be floor, wall, etc.

According to Tables C.2 and C.3 it is possible to calculate, as example values for a classroom of 50 m². Assuming a floor area of 2 m² per person, it is possible to find the number of persons in the room: 25.

The air flow rates referring to the building component, for the considered room, q_B, are shown in Table C.4. They do not change with reference to person adaptation.

Table C.4 — Building component of ventilation air flow rate for different types and categories of buildings

Categories	q _B (total for the classroom of 50 m ²)					
	Very low polluted buildings		Low polluted buildings		Non low polluted buildings	
	l/s	m ³ /h	l/s	m ³ /h	l/s	m ³ /h
I	25	90	50	180	100	360
II	17,5	63	35	126	70	252
III	10	36	20	72	40	144
IV	7,5	27	15	54	30	108

Then, the calculation consists in finding q_p, first for non-adapted persons and then for adapted ones. Results are included in Table C.5.

Table C.5 — Persons component of ventilation air flow rate for adapted and non-adapted persons and different categories of buildings

Categories	q _p (total for 25 persons)			
	Non adapted		Adapted	
	l/s	m ³ /h	l/s	m ³ /h
I	250	900	87,5	315
II	175	630	62,5	225
III	100	360	37,5	135
IV	62,5	225	25	90

After that, the air flow for persons has to be summed to the airflow for building surface. The results are reported as an example in Table C.6 considering the case of “low polluted buildings”.

Table C.6 — Total ventilation air flow rate for the case of low polluted building and different categories

q_{tot} (q_p+q_B for all students and classroom surface)							
Categories	q_B	Non adapted			Adapted		
	m ³ /h	q_p m ³ /h	q_{tot} m ³ /h	l/s per person	q_p m ³ /h	q_{tot} m ³ /h	l/s per person
I	180	900	1080	12	315	495	5,5
II	126	630	756	8,4	225	351	3,9*
III	72	360	432	4,8	135	207	2,3*
IV	54	225	279	3,1*	90	144	1,6*

The values marked with * are below the minimum of 4 l/s per person and, therefore, they have to be increased to guarantee 4 l/s per person.

The values in [Table C.2](#) can be recalculated to corresponding CO₂ values in the room. This is useful for CO₂ controlled ventilation systems. The recalculated values are given in [Table C.7](#).

Table C.7 — Example of equivalent increase in CO₂ levels indoor above outdoor for the total ventilation rates specified in [Table C.2](#)

Type of building or space	Category	Occupancy person/m ²	Δ CO ₂ [ppm]		
			Very low-polluting	Low-polluting	Not low-polluting
Single office	I	0,1	370	278	185
	II	0,1	529	397	265
	III	0,1	926	694	463
	IV	0,1	1 389	1 010	654
Landscaped office	I	0,07	317	222	139
	II	0,07	454	317	198
	III	0,07	741	556	347
	IV	0,07	1 235	794	483
Conference room	I	0,5	505	463	397
	II	0,5	722	661	567
	III	0,5	1 263	1 157	992
	IV	0,5	1 462	1 389	1 502
Auditorium	I	1,33	535	517	483
	II	1,33	765	738	690
	III	1,33	1 347	1 300	1 208
	IV	1,33	1 576	1 398	1 576
Restaurant	I	0,67	517	483	427
	II	0,67	738	690	611
	III	0,67	1 277	1 195	1 068
	IV	0,67	1 543	1 372	1 543
Classroom	I	0,5	505	463	397
	II	0,5	722	661	567
	III	0,5	1 263	1 157	992
	IV	0,5	1 543	1 389	1 502

NOTE In this table, CO₂ emission value is 20 l/h per person for sedentary, 23,3 l/h per person for kindergarten and (26,6 l/h per person for department store). Values in italics indicate situations where the calculated ventilation rate is lower than the minimum required 4 l/s per person.

Table C.7 (continued)

Type of building or space	Category	Occupancy person/m ²	ΔCO ₂ [ppm]		
			Very low-polluting	Low-polluting	Not low-polluting
Kindergarten	I	0,5	588	539	462
	II	0,5	841	771	660
	III	0,5	1 471	1 348	1 156
	IV	0,5	1 798	1 618	1 749
Department store	I	0,14	435	308	238
	II	0,14	621	440	341
	III	0,14	1 087	770	596
	IV	0,14	1 606	1 103	840

NOTE In this table, CO₂ emission value is 20 l/h per person for sedentary, 23,3 l/h per person for kindergarten and (26,6 l/h per person for department store). Values in italics indicate situations where the calculated ventilation rate is lower than the minimum required 4 l/s per person.

C.1.3 Method 2: Method using limit values of substance concentration

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

Table C.8 — Default design CO₂ concentrations above outdoor concentration assuming a standard CO₂ emission of 20 L/(h/person)

Category	Corresponding CO ₂ concentration above outdoors in PPM for non-adapted persons
I	550 (10)
II	800 (7)
III	1 350 (4)
IV	1 350 (4)

NOTE The above values correspond to the equilibrium concentration when the air flow rate is 10, 7 and 4 l/s per person for cat. I, II, and III, IV, respectively, and the CO₂ emission is 20 l/h per person.

Default outside concentration average can be assumed 400 ppm (350 ppm to 500 ppm).

C.1.4 Method 3: Method based on predefined ventilation flow rates

The required total ventilation is here expressed as l/s per person or l/s m². The rate per person includes the contribution from the building and the rate per m² include the contribution from the people.

C.2 Default design ventilation air flow rates for residential buildings

As specified in ISO 17772-1:2017, I.2, different methods can be used to determine the supply and exhaust ventilation rates. They are present because at international level different countries have different regulations and standards. Designers can therefore choose the method most adequate to any context.

ISO 17772-1 assumes complete mixing in the room (i.e. the concentration of pollutants is equal in exhaust and in occupied zone).

In ISO 17772-1:2017, Table I.6, three procedures based on design supply air flow rates, and in ISO 17772-1:2017, Tables I.8 and I.9, two procedures based on extract air flow rates. They have to be

used as alternative to each another. The result deriving from one method has not to be added to any other result coming out from another procedure.

According to all methodologies, residential ventilation design needs that all main rooms have to be provided with supply devices. It should not be possible to exclude bedrooms from air supply.

During usage of wet rooms or kitchen hoods, there can be some higher airflow period (boost) due to peaks of pollution (for example, ventilation rate is increased for half an hour).

Parameters on noise and draught risk have to be respected because, very often, users shut-off or alter ventilation devices causing discomfort (e.g. too much fresh air during the night, devices too noisy).

Ventilation rates can be achieved by different ventilation systems: mechanical, natural or hybrid (which combines mechanical and natural principles).

Mechanical ventilation

Mechanical residential ventilation systems mostly consist of self-contained equipment with elementary air ducts if needed. There is a wide range of devices and related EN standards covering the characteristics, the evaluation of performance and the classification of residential ventilation systems (EN 13142 and EN 13141-1 to EN 13141-11). A brief description is given below.

a) Mechanical exhaust ventilation systems

Fresh air enters the main-rooms through suitable inlet devices, transits through doors or other openings toward the wet-rooms and then is exhausted by one or more fans. The inlet and outlet devices can be equipped with flow rate controls, e.g. self-regulating, to maintain constant flow rate, or based on humidity, CO₂ concentration, presence, to adjust the flow rate to the effective requirement (DCV). Inlet devices are usually located in the external walls or on the windows; the air ducts are limited to connect the extract devices with the fan(s) and from the fan(s) to the exterior (exhaust).

b) Mechanical supply ventilation systems

Fresh air is supplied by one or more fans to the main-rooms at constant or variable (DCV) flow rate through a suitable air duct network and inlet devices, transits through doors or other openings toward the wet-rooms and then is exhausted possibly by one or more fans. In this last case, fans can be operated according to different schedule: upon request (with or without switch-off delay after use), manually or automatically. Inlet and outlet devices can be as in case a). They are not common because exhaust systems are more used across Europe. Their use has to be carefully evaluated since a good exhaust of pollution from wet rooms has to occur as for exhaust systems.

c) Mechanical balanced ventilation systems

In these systems, supply and exhaust air flow rates are introduced in main-rooms, transfer to wet rooms through doors passage or specific devices and extracted from these wet rooms. This is achieved through suitable air duct networks and inlet or outlet devices by means of separate fans. Usually, energy recovery from the exhaust air is performed by a heat exchanger or a heat pump. Different strategies of air flow control (DCV and/or boost airflow) can be used.

d) Mechanical un-ducted units for single room systems

Air flow is supplied to each main room by a specific device equipped with a fan. Some types are equipped also with an extraction fan and recovery heat exchanger. Air from wet rooms is extracted by specific fans which can be operated according to different schedule according to national rules or design purposes: upon request (with or without switch-off delay after use), manually or automatically.

In all cases, when multispeed exhaust devices are used, the peak value should be operated when needed (i.e. during the creation of pollution induced by the use of room, as the cooking time for the kitchen, etc.) and for a suitable time after the use to allow to decrease the pollution concentration properly. For

instance, it is not enough to ventilate a bathroom during the bath period, a time control or humidity control is needed to continue ventilation as long as needed after occupation.

Natural ventilation

Residential natural ventilation systems use stack effect and wind pressure to drive the ventilation airflow through the building. Typical inlet components are facade grilles, window grilles, roof window ventilation flaps and air inlet. Typical extract components include extract stack ducts. The system is typically designed to allow air entry in living rooms and bedrooms, and to extract air from kitchens, toilets and bathrooms. The operation of the ventilation system can be based on always-open ventilation openings, which provides acceptable indoor air quality on weekly, monthly and annual level. The operation can also be automated, based on sensors of, for example, humidity or CO₂.

Airing

Since airing is the air change by manually operating windows or other openings, it has to be observed that it cannot be considered a ventilation system.

C.2.1 Design supply air flow rates

The following examples are based on ISO 17772-1:2017, Table I.6, according to which, it is possible to choose three different design possibilities:

- criteria based on air changes per hour;
- criteria based on supply air flow per person;
- supply air flow based on perceived IAQ for adapted persons.

The three criteria are hereafter described.

1) Criteria based on air changes per hour

According to this method, the supply air flow rate, in m³/h, is calculated as the product of the total volume of the dwelling (or the room) and the coefficient of ISO 17772-1:2017, Table I.6 expressed in h⁻¹ for different internal heights, to take into account the different volume of the rooms.

Table C.9 — Examples of equivalent values of air change rate for different room heights

Internal height	2,5 m	2,7 m	3 m
Corresponding values of ACH	0,5 h ⁻¹	0,47 h ⁻¹	0,41 h ⁻¹
	0,6 h ⁻¹	0,56 h ⁻¹	0,5 h ⁻¹
	0,7 h ⁻¹	0,65 h ⁻¹	0,58 h ⁻¹

2) Criteria based on supply air flow per person

According to this method, the supply air flow rate, in l/s, is calculated as the product of the design number of persons in the dwelling (or in the room) and the coefficient of ISO 17772-1:2017, Table I.6 expressed in l/s per person.

Results obtained with this method are not depending by the internal height.

3) Criteria based on supply air flow based on perceived air quality for adapted persons

ISO 17772-1 introduces the concept of binomial calculation similarly to the case of non-residential ventilation: a part of the supply air is intended compensate the emission from persons and a part the emissions from the building components. ISO 17772-1:2017, Formula (1) applies with a difference: A_R is the total dwelling main room’s floor area.

With this method, the total air flow for the whole dwelling is therefore calculated according to ISO 17772-1:2017, Table I.6, where the related values of q_p and q_B are given in column (3).

The method takes into account that the persons should be considered once.

Results obtained with this method are not depending by the internal height.

Examples of air flow rate calculation

Some examples of application of the three methodologies are hereafter presented for different dwelling sizes. It has to be noticed that all the examples propose only one of the several possible solutions. The examples concerns only the case of constant air flow rate.

Examples 1, 2 and 3 show the design principle of different ventilation systems respectively for:

- a one-bedroom dwelling;
- a two-bedroom dwelling;
- a three-bedroom dwelling.

The air flow for each room is attributed by the designer.

All main rooms have to be provided with supply air inlet devices. Exhausts occur from kitchen, bathrooms and toilets: all of them have to be provided with exhaust devices.

The dimensioning of the system concerns its maximum capacity. During the operation time, the air flow rates can be different (as for example when persons are outside, the air flow rate can be reduced).

Example 1) Design example of a one-bedroom dwelling

The following example refers to a small dwelling with one bedroom (Figure C.1). The arrows show in which rooms supply and exhaust occur. Near the arrows a dimensioning example is proposed based on the calculation developed below according to category II, ACH method.

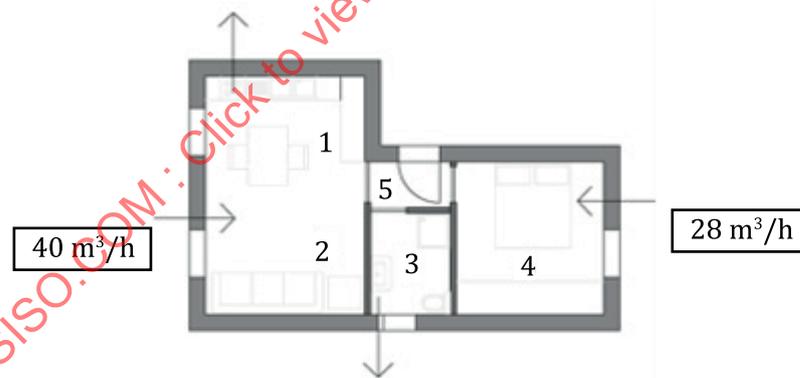


Figure C.1 — Dwelling plan

The characteristics of the considered dwelling are shown in Table C.10.

Table C.10 — One-bedroom dwelling dimensions

Room	Name	Surface (m ²)	Volume (m ³) (internal height: 2,5 m)	Example of dimensioning for ACH calculation, category II
1	Kitchen	8,6	21,5	Exhaust
2	Living room	15,4	38,5	Supply: 40 m ³ /h
3	Bathroom	5,4	13,5	Exhaust

Table C.10 (continued)

Room	Name	Surface (m ²)	Volume (m ³) (internal height: 2,5 m)	Example of dimensioning for ACH calculation, category II
4	Bedroom	16	40	Supply: 27 m ³ /h
5	Corridor	2,3	5,75	Transit
Total		47,7	119,25	

In the next paragraphs, calculation examples are explained step by step.

Calculation of supply airflow rates based on air changes per hour

Column (1) of ISO 17772-1:2017, Table I.6 is the reference for this calculation. The total dwelling volume has to be multiplied by the corresponding ACH value for each category as shown in [Table C.11](#). Once determined the air flow rate, it is possible to calculate the corresponding l/s per person present in the dwelling.

Table C.11 — Calculation of air flow rates for the one-bedroom dwelling based on ach

Categories	ACH	Total flow rates m ³ /h	Corresponding l/s per person	
			(1 person)	(2 persons)
I	0,7	77,51	23,25	11,65
II	0,6	66,78	20	10,00
III	0,5	56,05	16,81	8,40
IV	0,4	47,7	14,30	7,15

As an example, a complete calculation procedure is shown for category II.

In order to find the supply air flow rate, the dwelling volume, which is 119,25 m³, has to be multiplied by the air change value of ISO 17772-1:2017, Table I.6, for category II, which is 0,6: the result is 67 m³/h.

This value represents the reference total amount of air flow that has to be supplied partially in the living room and partially in the bedroom. Several possibilities to share the amount of the calculated ventilation air flow among the two main rooms (living room and bedroom) exist; the supply criteria is chosen by the designer according to different reasons as for example the dwelling dimensions, the ventilation system (centralized or decentralized, exhaust, supply or balanced) and the air flow control (constant flow or DCV).

In this case, it is interesting to notice that 66,78 m³/h is a relatively low value by itself and the market does not offer many possible sizes of supply and exhaust devices to be combined in order to achieve the required flow rate (some approximation can be tolerated).

Calculation of supply airflow rates based on air flow rate per person

Column (2) of ISO 17772-1:2017, Table I.6 is the reference for this calculation. In order to find the supply air flow rates the design number of persons has to be multiplied by the corresponding l/s/person value for each category as shown in [Table C.12](#). Once determined the flow rate, it is possible to calculate the corresponding values in m³/h or ACH.

Table C.12 — Calculation of air flow rates for the one-bedroom dwelling based on l/s/person

Categories	1 person			2 persons		
	l/s	Corresponding values		l/s	Corresponding values	
		m ³ /h	ach		m ³ /h	ach
I	10	36	0,30	20	72	0,60
II	7	25,2	0,21	14	50,4	0,42
III	4	14,4	0,12	8	28,8	0,24

As an example, a complete calculation procedure is performed for category II.

The number of persons in the dwelling, two in this case, has to be multiplied by the corresponding l/s/person value of category II which is 7 l/s: the result is 14 l/s which correspond to 50,4 m³/h. The result expressed in m³/h is useful in order to choose the components' size, normally identified by m³/h in commercial catalogues. For further evaluations, it is possible also to calculate the corresponding air changes per hour, dividing the total air flow rate expressed in m³/h by the dwelling volume, which means: 50,4 m³/h divided by 119,25 m³, that is 0,42 ACH.

Calculation of supply airflow rates based on perceived IAQ for adapted persons

Column (3) of ISO 17772-1:2017, Table I.6 is the reference for this calculation, which has to be done in three steps. First, the design number of persons has to be multiplied by the corresponding l/s/person value; second the main rooms' surface has to be multiplied by the corresponding l/s/m² value and finally the two obtained values have to be summed for each category as shown in [Table C.13](#). Once the total air flow rate is determined, it is possible to calculate the corresponding values in m³/h or ACH.

Table C.13 — Calculation of air flow rates for the one-bedroom dwelling based on l/s/person

Categories	1 person			2 persons		
	l/s	Corresponding values		l/s	Corresponding values	
		m ³ /h	ach		m ³ /h	ach
I	11,35	40,86	0,34	7,42	53,46	0,45
II	7,21	25,95	0,22	4,85	34,96	0,29
III	4,64	16,70	0,14	3,07 (4)	22,10 (28,8)	0,19 (0,22)

As an example, a complete calculation procedure is performed for category II.

The first step is to multiply the person's number in the dwelling, two in this case, by the corresponding l/s/person value of category II which is 2,5 l/s: the result is 5 l/s which correspond to 18 m³/h.

Then, the main rooms total surface, 31,4 m² in this case, has to be multiplied by the corresponding l/s/m² value of category II which is 0,15 l/s: the result is 4,71 l/s which corresponds to 16,96 m³/h.

The third step consists in summing the two previous results (5 l/s + 4,71 l/s) to find the total supply air flow that is 9,71 l/s, corresponding to 34,96 m³/h.

For further evaluations, it is possible also to calculate the corresponding air changers per hour, dividing the total air flow rate expressed in m³/h by the dwelling volume, which means: 34,96 m³/h divided by 119,25 m³, that is 0,29 ACH.

Example 2) Design example of two-bedrooms dwelling

The following example refers to a medium dwelling with two bedrooms (Figure C.2). The arrows show in which rooms supply and exhaust occur. Near the arrows, a dimensioning example is proposed based on the calculation developed below according to category II, ACH method and 3 persons.



Figure C.2 – Dwelling plan

The characteristics of the considered dwelling are shown in Table C.14.

Table C.14 – Two-bedroom dwelling dimensions

Room	Name	Surface (m ²)	Volume (m ³) (internal height: 2,5 m)	Example of dimensioning for ACH calculation, category II.
1	Kitchen	11,2	28	Exhaust
2	Living room	14,8	37	Supply: 40 m ³ /h
3	Bathroom	5	12,5	Exhaust
4	Toilet	3,20	8	Exhaust
5	Bedroom 1	12	30	Supply: 25 m ³ /h
6	Bedroom 2	16	40	Supply: 35 m ³ /h
7	Corridor	5,2	13	transit
Total		67,4	168,5	

For this example, the calculation is done only considering the ACH method for all the categories. In order to apply the other two methodologies, the designer can refer to the same procedures described in example one.

Column (1) of ISO 17772-1:2017, Table I.6 is the reference for this calculation and the results obtained are shown in Table C.15.

Table C.15 — Calculation of air flow rates for the two-bedroom dwelling based on ACH

Categories	ACH	Total flow rates m ³ /h	Total flow rates l/s	Corresponding l/s per person	
				(2 person)	(3 persons)
I	0,7	117,95	32,76	16,38	10,92
II	0,6	101,1	28,08	14,04	9,36
III	0,5	84,25	23,40	11,70	7,80
IV	0,4	67,4	18,72	9,36	6,24

Example 3) Design example of three-bedroom dwelling

The following example refers to a large dwelling with three bedrooms (Figure C.3). The arrows show in which rooms supply and exhaust occur. Near the arrows, a dimensioning example is proposed based on the calculation developed below according to category II, ACH method and 5 persons.

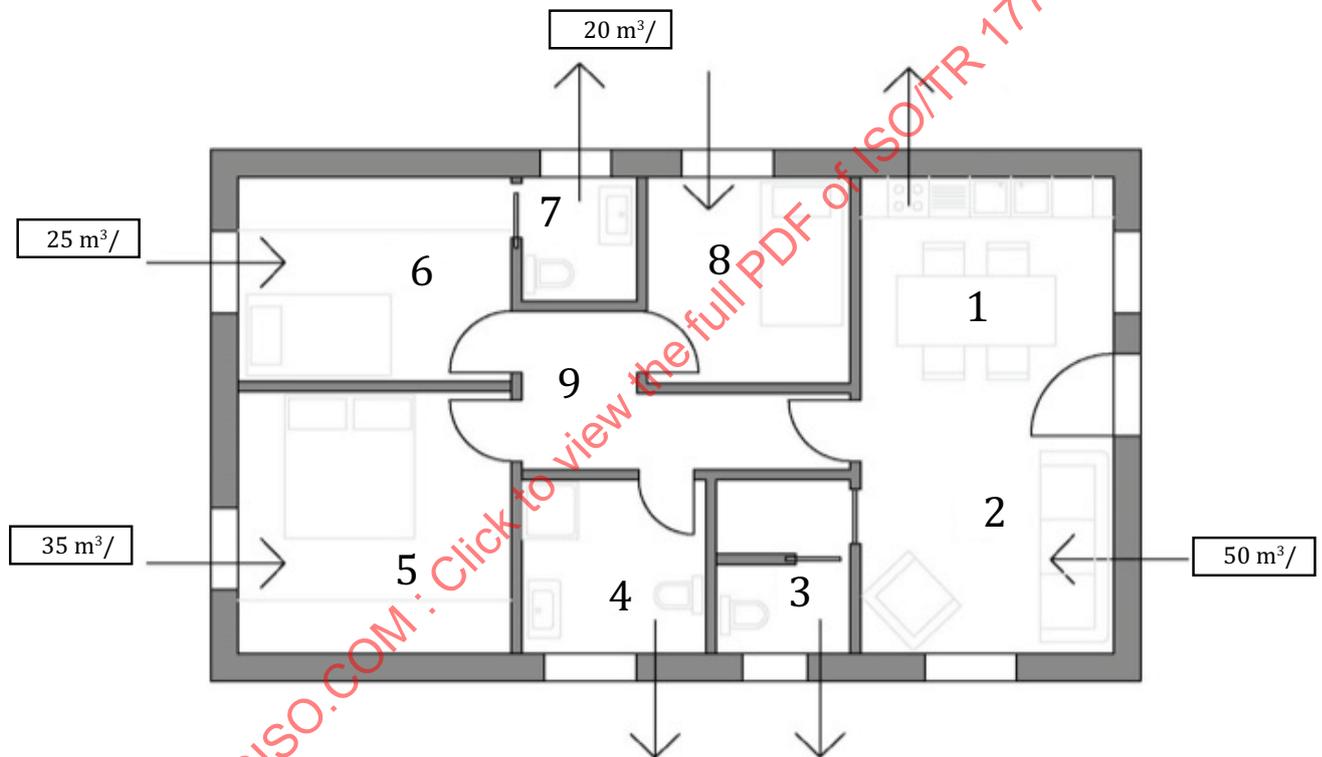


Figure C.3 — Dwelling plan

The characteristics of the considered dwelling are shown in Table C.16.

Table C.16 — Three-bedroom dwelling dimensions

Room	Name	Surface (m ²)	Volume (m ³) (internal height: 2,5 m)	Example of dimensioning for ACH calculation, category II
1	Kitchen	11,2	28	Exhaust
2	Living room	14,8	37	Supply: 50 m ³ /h
3	Toilet 1	4,50	11,25	Exhaust
4	Bathroom	6,70	16,75	Exhaust
5	Bedroom 1	16	40	Supply: 35 m ³ /h
6	Bedroom 2	12	30	Supply: 25 m ³ /h

Table C.16 (continued)

Room	Name	Surface (m ²)	Volume (m ³) (internal height: 2,5 m)	Example of dimensioning for ACH calculation, category II
7	Toilet 2	3	7,5	Exhaust
8	Bedroom 3	9	22,5	Supply: 20 m ³ /h
9	Corridor	7,50	18,75	transit
Total		84,7	211,75	

For this example, the calculation is done only considering the ACH method for all the categories. In order to apply the other two methodologies, the designer can refer to the same procedures described in example one.

Column (1) of ISO 17772-1:2017, Table I.6 is the reference for this calculation and the results obtained are shown in [Table C.17](#).

Table C.17 — Calculation of air flow rates for the three-bedroom dwelling based on ACH

Categories	ACH	Total flow rates, m ³ /h	Corresponding l/s per person		
			(3 person)	(4 persons)	(5 persons)
I	0,7	148,23	13,72	10,29	8,23
II	0,6	127,05	11,76	8,82	7,06
III	0,5	105,88	9,80	7,35	5,88
IV	0,4	84,70	7,84	5,88	4,71

C.2.2 Design extract air flow rates

This method consists in dimensioning the exhaust air flow rates which establish the maximum capacity of the system. Then, the inlet devices are dimensioned as a consequence, to balance the system. According ISO 17772-1:2017, Table I.8, the first step consists in identifying how many main rooms in the dwelling are present. In the next step, the total extract air flow rate is calculated.

The following examples consider the same dwelling size of [C.2.1](#).

Example 1: One-bedroom dwelling

In example 1, a one-bedroom dwelling is taken into consideration. Its plan is in [Figure C.4](#) and its dimensional characteristics are summarized in [Table C.18](#).

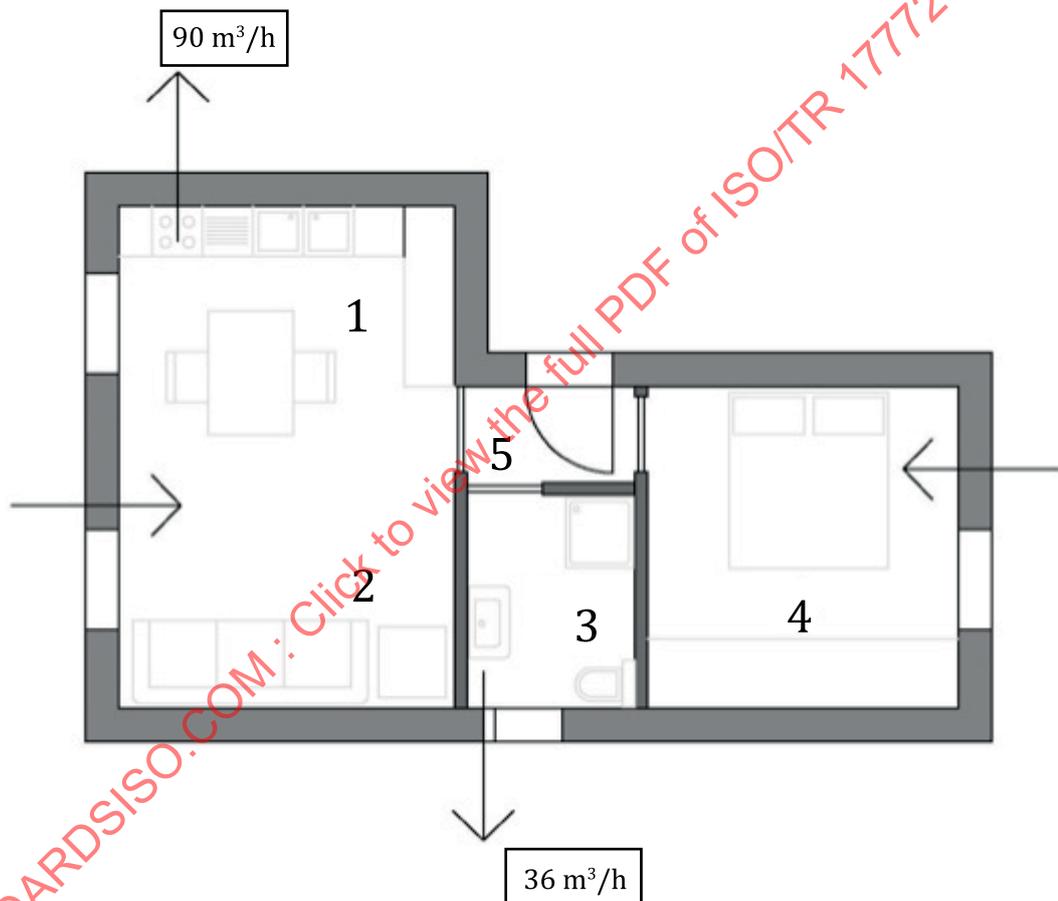
In this example, there are two main rooms: living room and bedroom. According to ISO 17772-1:2017, Table I.8 when two main rooms are present, the extract air flow rates are respectively: 25 l/s for the kitchen and 10 l/s for all the other wet rooms. So, in this example, the extract air flow rates are, respectively, 25 l/s for the kitchen and 10 l/s for the only one bathroom present, as shown in [Table C.18](#).

Because in this example category II is chosen as the reference, the air flow rates above calculated have to be multiplied according to the coefficient of ISO 17772-1:2017, Table I.9 which is 1. So the previous results do not change.

Table C.18 — Calculation of extract air flow rates for the one-bedroom dwelling

EXAMPLE 1 main rooms number in the dwelling: — one bedroom — one living room	Design extract air flow rates in l/s				
	Kitchen	Bathroom or shower with or without toilets	Other wet room	Toilets	
				Single in dwelling	Multiple (2 or more in dwelling)
2	25 (90 m ³ /h)	10 (36 m ³ /h)	Not present	Not present	Not present

For this dwelling, a total of 35 l/s, which correspond to 126 m³/h, defines the maximum capacity of the system (boost level). The same airflow rate value is used to dimension the supply net. [Figure C.4](#) shows how exhausts occur in a small dwelling with two main rooms.

**Figure C.4 — Dwelling plan****Example 2: Two-bedroom dwelling**

In example 2, a two-bedroom dwelling is taken into consideration. Its plan is in [Figure C.2](#) and its dimensions are summarized in [Table C.14](#). Calculations are done with reference to category II. And are summarized in [Table C.19](#). In order to find a calculation step by step, reference to example 1).

Table C.19 — Calculation of extract air flow rates for the two-bedroom dwelling

EXAMPLE 2 main rooms number in the dwelling: — two bedrooms — one living room	Design extract air flow rates in l/s				
	Kitchen	Bathroom or shower with or without toilets	Other wet room	Toilets	
				Single in dwelling	Multiple (2 or more in dwelling)
3	30	15	Not present	Not present	Not present

Therefore, for this dwelling, a total of 45 l/s, which correspond to 162 m³/h, defines the maximum capacity of the system (boost level).

Example 3: three-bedroom dwelling

In example 3, a three-bedroom dwelling is taken into consideration. Its plan is in [Figure C.3](#) and its dimensional characteristics are summarized in [Table C.16](#). Calculations are done with reference to category II and are summarized in [Table C.20](#). In order to find a calculation step by step, refer to example 1).

Table C.20 — Calculation of extract air flow rates for the three-bedroom dwelling

EXAMPLE 3 main rooms number in the dwelling: — three bedrooms — one living room	Design extract air flow rates in l/s				
	Kitchen	Bathroom or shower with or without toilets	Other wet room	Toilets	
				Single in dwelling	Multiple (2 or more in dwelling)
3	35	15	10	10	Not present

Therefore, for this dwelling, a total of 70 l/s, which corresponds to 252 m³/h, defines the maximum capacity of the system (boost level).

C.2.3 Design opening area for natural ventilation

This method is mostly used in systems based on passive grilles and stack ducts. Inlet grilles are typically positioned in each bedroom and living room, while exhaust stack ducts are positioned in bathrooms and kitchen.

[Figure C.5](#) ([Table C.16](#)) shows the design principle of a natural ventilation system based on extract stack ducts and supply grilles or similar openings. Exhaust stack ducts from kitchen and bathrooms should end at the roof ridge, as there will be suction (under pressure) at this location of the roof independently of the wind direction. The example is based on a supply grille area of 60 cm² or 25 m² floor area, and 100 cm² extract duct area.

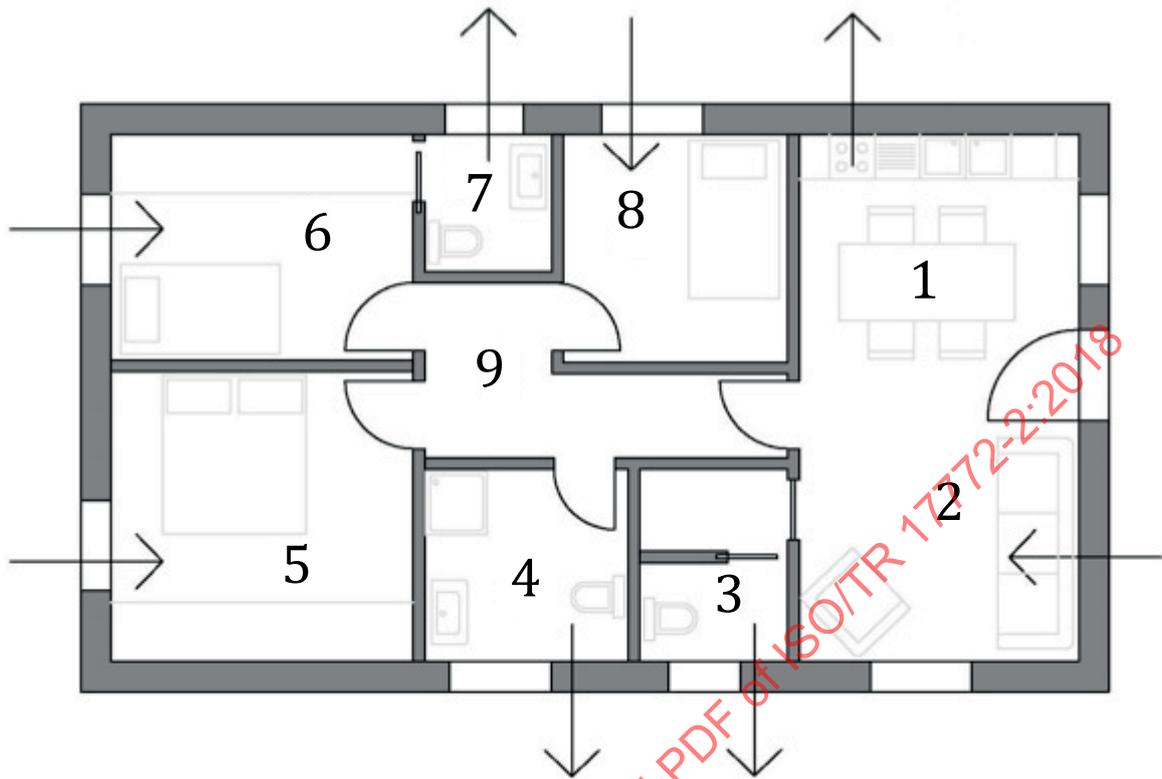


Figure C.5— Dwelling plan

C.3 Recommended criteria for dimensioning of humidification and dehumidification

In places where humidity criteria are set by human occupancy, if humidification or dehumidification is used, the values in the ISO 17772-1:2017, Table I.11 are recommended as design values under design conditions. Usually, humidification or dehumidification is needed only in special buildings (e.g. museums, some health care facilities, process control, paper industry, etc.).

C.4 Recommended ventilation during non-occupied hours

During unoccupied periods, it is possible to reduce the ventilation rate and also fully stop the ventilation system. To avoid unacceptable air quality when occupied again, it is necessary to include a constant basic ventilation or increased ventilation before occupancy.

Annex D (informative)

Example on how to define low and very low polluting buildings

Many interior construction and finishing products will emit pollutants into indoor air with the potential to deteriorate indoor air quality. Ventilation can flush out these emitted pollutants. Operating a building at low ventilation (as specified in this document,) increases the risk of air pollution by these emitted substances and requires designing a building with low polluted interior spaces. This is done by selecting low emitting materials, especially for the large surfaces (walls, floors, ceilings). A simple way is to identify and select materials that are labelled to show conformity with legislative or voluntary specifications of low VOC emissions. The building is low or very low polluted if at least 80 % of the interior materials are low or very low emitting.

Low or very low emitting materials are stone, glass, ceramics and certain non-treated metals, which are known to show no emissions into indoor air, and materials that show low or very low emissions (see [Table D.1](#)) when tested. Emissions properties are evaluated by testing the material after 28 days' storage in a ventilated test chamber, in line with CEN/TS 16516 in combination with ISO 16000-11, or as specified in ISO 16000-3/ISO 16000-6/ISO 16000-9/ISO 16000-11. The emission rates obtained by this experiment are then transformed into air concentrations in the European Reference Room as specified in CEN/TS 16516, see [Table D.2](#).

In countries with compulsory legal requirements, these are assumed to provide the minimum requirements (low emitting materials), while voluntary labels set the benchmark for very low emitting materials, see [Table D.1](#). This holds true even for the French VOC regulation with different VOC emissions classes: even the most stringent legal VOC emissions class (A+) has less stringent requirements for most involved substances (except formaldehyde) than the voluntary labels specified. This allows a classification of VOC emissions on three levels (not low emitting, low emitting or very low emitting).

Therefore, low emitting products for low polluted buildings are those that comply with legal requirements as, for example, in:

- Belgium;
- France (VOC emissions class B or better) - with the exception of R value which is not specified;
- Germany (AgBB/DIBt).

The limits for very low emitting products for very low polluted buildings are based on a survey of the specifications of popular eco labels for very low emitting products, such as:

- Blue Angel;
- EMICODE EC1;
- GUT;
- Indoor Air Comfort.

Some other labels are also included in this approach, but they include even lower limit values:

- EMICODE EC1PLUS;
- Indoor Air Comfort Gold;
- M1.

The approach is that it would not serve the purpose of this standard to refer only to the labels with the lowest limit values, but also to include labels with reasonably low limit values.

Any emission is expressed as room concentration under conventional conditions (see [Table D.1](#)), after calculation with the parameters of the European Reference Room (see [Table D.2](#)). Such tests correspond to emissions four weeks after finalizing a building. These are assumed to be an indicator of the long-term emissions in a building.

Table D.1 — Limit values after 28 days' storage in a ventilated test chamber

	Low emitting products for low polluted buildings	Very low emitting products for very low polluted buildings	Unit
Total VOCs (TVOC) (as in CEN/TS 16516)	1 000	300	µg/m ³
Formaldehyde	100	30	µg/m ³
Any C1A or C1B classified carcinogenic VOC **	5	5	µg/m ³
R value (as in CEN/TS 16516)	1,0	1,0	—
* VOC = Volatile organic compounds, as defined in CEN/TS 16516.			
** Some requirements go for a limit of 1 µg/m ³ , sometimes with the extension "as far as technically feasible". As such low emissions cannot be determined in a reliable manner for most VOCs, a limit of 5 µg/m ³ for any VOC is on the safe side for a reliable determination of emissions.			

The air concentrations in [Table D.1](#) refer to the European Reference Room (as specified in CEN/TS 16516:2013) which has the following parameters:

Table D.2 — European Reference Room

Floor	3 m × 4 m	Air change rate	0,5 h ⁻¹ (15 m ³ /h)
Height	2,5 m	Temperature	23 °C
Volume	30 m ³	Relative humidity	50 %
Window	1 window of 2 m ²	Door	1 door of 1,6 m ² (0,8 m × 2,0 m)

The emissions are calculated for each product using the conventional loading factors presented in [Table D.3](#) (as specified in CEN/TS 16516:2013).

Table D.3 — Product loading factors

Intended use on	Loading factor m ² /m ³	Area specific air flow m ³ /m ² h
Walls	1,0	0,5
Floor or ceiling	0,4	1,25
Small surfaces (e.g. a door) (1,6 m ² to 2 m ²)	0,05	10
Very small surfaces (e.g. sealants)	0,007	72

Conformance can be shown in the following two ways:

- presenting a test report, issued by a testing laboratory with an ISO 17025 accreditation that covers this type of test;
- showing a valid attestation of compliance with any regulation or voluntary label that includes the above (or more stringent) limit values (see [Table D.1](#)) after 28 days' storage in a ventilated test chamber (or earlier).

An estimation of the air pollution of a real room will suffer from the facts that, even though this is possible as mathematical calculation, the once determined emissions will vary significantly in real life in this possible way:

- over time, with high decrease of emission during the first days and weeks (the testing after 28 days' storage in a ventilated test chamber is assumed to indicate somehow stable long-term emissions);
- over production batches;
- with differences and variations in temperature and relative humidity during installation of the product and during operation of the building.

Therefore, the selection of low emitting or very low emitting products only helps to achieve good indoor air quality by avoiding higher emitting products. Designing air quality precisely based on emissions data are not a realistic option for the above mentioned reasons. Nevertheless, if such estimation is foreseen, then the calculation follows cross-multiplication ("rule of three"):

$$c_B = c_R \times L_{AB}/L_{AR} \times AC_R/AC_B \quad (D.1)$$

where

- c_B is the mass concentration of compound a in the air of the actual building, in $\mu\text{g}/\text{m}^3$;
- c_R is the mass concentration of compound a in the air of the reference room, in $\mu\text{g}/\text{m}^3$;
- L_{AB} is the loading factor in the actual building, in square metre sample per cubic meter reference room;
- L_{AR} is the loading factor in the reference room, in square metre sample per cubic meter reference room;
- AC_R is the hourly air change rate in the reference room, in h^{-1} ;
- AC_B is the hourly air change rate in the actual building, in h^{-1} .

[Formula \(D.1\)](#) can be applied:

- to the maximum expected air concentrations, as given by the limit values, if these are respected;
- to the actually detected emissions in the air of the reference room, if the above mentioned limitations of such calculations are taken into account.

Annex E (informative)

Examples of criteria for lighting

Table E.1 — Examples of criteria for some buildings and spaces according to EN 12464-1:2011

Clause reference	Type of area, task or activity	\bar{E}_m lx	Specific requirements
5.26.2	Offices — Writing, typing, reading, data processing	500	DSE-work, see 4.9
5.26.5	Offices — Conference and meeting rooms	500	Lighting should be controllable.
5.36.1	Educational buildings — Classrooms, tutorial rooms	500	Lighting should be controllable.
5.36.2	Educational buildings — Classroom for evening classes and adult's education	500	Lighting should be controllable.
5.36.3	Educational buildings — Auditorium, lecture halls	500	Lighting should be controllable to accommodate various A/V needs.
5.39.1	Health care premises — Wards, maternity wards — General lighting	100	
5.39.3	Health care premises — Wards, maternity wards — Simple examinations	300	
5.40.1	Health care premises — Examination rooms (general) — General lighting	500	$4\ 000\ K \leq T_{CP} \leq 5\ 000\ K$
5.40.2	Health care premises — Examination rooms (general) — Examination and treatment	1 000	
5.29.3	Places of public assembly — Restaurants and hotels — Restaurant, dining room, function room	—	The lighting should be designed to create the appropriate atmosphere.
5.36.24	Educational premises — Educational buildings — Sports halls, gymnasiums, swimming pools	300	See EN 12193 for training conditions.
5.27.1	Retail premises — Sales area	300	
5.27.2	Retail premises — Till area	500	
5.1.1	Traffic zones inside buildings — Circulation areas and corridors	100	<ul style="list-style-type: none"> — Illuminance at floor level. — Ra and UGR similar to adjacent areas; — 150 lx if vehicles on the route; — The lighting of exits and entrances will provide a transition zone to avoid sudden changes in illuminance between inside and outside by day or night. Care should be taken to avoid glare to drivers and pedestrians.
5.1.2	Traffic zones inside buildings — Stairs, escalators, travellers	100	Requires enhanced contrast on the steps.

Annex F (informative)

Indoor system noise criteria of some spaces and buildings

F.1 Noise from continuous sources

The values of equivalent sound pressure levels given in ISO 17772-1:2017, Table L.1 are the basis for the design of the relevant equipment. To achieve the proposed results, suitable reliable values of sound power level L_w should be used adequately documented by official tests such as those according to EN 13141-1 to EN 13141-11 for residential applications and EN 13053 for non-residential applications. From sound power level, the resulting sound pressure level can be derived, taking into account the dimensions and the acoustic characteristics of the considered room, by resorting to the following relationship ([Formula F.1](#)) between sound power and sound pressure level:

$$L_p = L_w + 10 \log \left[\frac{Q}{4\pi r^2} + \frac{4}{R} \right] \quad (\text{F.1})$$

where

L_p is the sound pressure level, dB (re 20 μPa);

L_w is the sound power level, dB (re 10^{-12} W);

Q is the directivity of sound source, dimensionless;

r is the distance from source, m;

R is the room constant, dimensionless.

$$R = \frac{A}{1 - \frac{A}{S_t}} \quad \text{and} \quad A = 0,161 \frac{V}{T_0}$$

where

A is the total equivalent acoustic absorption, m^2 ;

S_t is the total inner surface of the room, m^2 ;

V is the volume, m^3 ;

T_0 is the reverberation time, s.

The reverberation time T_0 can be assumed 0,5 s for room volume up to 150 m^3 , otherwise it can be calculated according to dimensions and characteristics of the room or to specific regulations, if any.

Example of use of [Formula \(F.1\)](#)

In the following example, a ventilation device has to be installed in a room with these dimensions: floor surface of $4 \text{ m} \times 4 \text{ m}$, height of $2,5 \text{ m}$ and volume of 40 m^3 . The device has to be installed on a wall: therefore, the directivity factor can be assumed to be $Q = 2$; let's assume a sound power level $L_w = 35 \text{ dB}$. In this case, a suitable reference position for the design calculation process can be the centre of the room: let the distance from this point and the device be 2 m .

The first step is to calculate the total inner surface of the room, which is:

$$S_t = 16 + 16 + 4 \times 10 = 72 \text{ m}^2$$

The second step, considering the reverberation time as 0,5 s, is to calculate A and R as follows:

$$A = 0,161 \times 40 / 0,5 = 12,88 \text{ m}^2 \text{ and } R = 12,88 / (1 - 12,88 / 72) = 15,68 \text{ m}^2$$

The third step is to use [Formula \(F.1\)](#) to predict the pressure level in the room deriving from the assumed power level as follows:

$$L_p = 40 + 10 \log [2 / (4 \pi r^2) + 4 / 15,68] = 40 - 5,30 = 34,70 \text{ dB}$$

The calculation can be repeated for any relevant band of frequency (e.g. 125 Hz to 4 000 Hz) and the resulting A-weighted sound pressure level can be derived and compared with the selected value from ISO 17772-1:2017, Table L.1.

In the post-operation assessment, the measured values should be normalized to the reverberation time assumed at design stage, by adding the following term:

$$10 \log (T/T_0)$$

where

T is the reverberation time at measurement conditions;

T_0 is the design reverberation time.

F.2 Noise from service equipment in buildings

With reference to [6.6](#), some design values of $L_{AFmax, nT}$ are given in [Table F.1](#).

Table F.1 — Examples of design sound level, $L_{AFmax, nT}$, [dB(A)] for non-continuous sources

Building	Sound level, $L_{AFmax, nT}$, [dB(A)]		
	I	II	III
Residences	<32	<36	<40
Hotel rooms	<30	<34	<38
Hospital patient room	<30	<34	<38
Offices	<32	<36	<40

Annex G (informative)

Occupants schedules for energy calculations

The occupant schedules have a very significant influence on the calculate energy performance. Therefore, ISO 17772-1 includes several default schedules that can be used for a standard calculation. The following shows how the dry and total heat loss from the human body is calculated.

Heat emission from human body depends on many factors such as room temperature, mean radiant temperature, relative humidity, air velocity, body surface area, metabolic rate, clothing insulation, etc. Indoor climate in winter and summer, following the specification of this standard, therefore has an effect leading to different seasonal values of heat emission.

Body surface area is a unique parameter and it depends on individual height and weight. It is the most significant parameter and it shows large variation among occupants with similar amount of muscular activity. In addition, heat loss by skin diffusion, radiation and convection depend on body surface area. The body surface area is calculated with the Du Bois formula which considers 50 percentile weight and height of corresponding age and sex^[4].

$$A_{DU} = 0,202 \times W^{0,425} \times H^{0,725} \quad (G.1)$$

where

A_{DU} is the body surface area;

W is the weight, kg;

H is the height, m.

In building categories under interest, the highest variation of body surface area of occupants occurs in day care centres, kindergartens and schools compared to other building categories mainly occupied by adults (detached houses, apartment buildings, office buildings, departmental stores, hotels, restaurants, sport halls and hospitals). [Table G.1](#) shows the body surface area based on weight and height.

Table G.1 — Body surface area of occupants in day care centre, kindergarten and school^[5]

	Age	Girl/Female					Boy/Male				
		W		H		A_{DU}	W		H		A_{DU}
		lb	kg	inch	m		lb	kg	inch	m	
Day care centre	2	26,5	12,0	33,5	0,9	0,5	27,5	12,5	34,2	0,9	0,5
	3	31,5	14,3	37,0	0,9	0,6	31,0	14,1	37,5	1,0	0,6
	4	34,0	15,5	39,5	1,0	0,6	36,0	16,4	40,3	1,0	0,7
Kindergarten	5	39,5	18,0	42,5	1,1	0,7	40,5	18,4	43,0	1,1	0,7
	6	44,0	20,0	45,5	1,2	0,8	45,5	20,7	45,5	1,2	0,8
School											
G - 1	7	49,5	22,5	47,7	1,2	0,9	50,5	23,0	48,0	1,2	0,9
G - 2	8	57,0	25,9	50,5	1,3	1,0	56,5	25,7	50,4	1,3	1,0
G - 3	9	62,0	28,2	52,5	1,3	1,0	63,0	28,6	52,5	1,3	1,0
G - 4	10	70,5	32,0	54,5	1,4	1,1	70,5	32,0	54,5	1,4	1,1

Table G.1 (continued)

	Age	Girl/Female					Boy/Male				
		W		H		A_{DU}	W		H		A_{DU}
		lb	kg	inch	m	m ²	lb	kg	inch	m	m ²
G - 5	11	81,5	37,0	56,7	1,4	1,2	78,5	35,7	56,5	1,4	1,2
G - 6	12	91,5	41,6	59,0	1,5	1,3	88,0	40,0	58,7	1,5	1,3
G - 7	13	101,0	45,9	61,7	1,6	1,4	100,0	45,5	61,5	1,6	1,4
G - 8	14	105,0	47,7	62,5	1,6	1,5	112,0	50,9	64,5	1,6	1,5
G - 9	15	115,0	52,3	62,9	1,6	1,5	123,5	56,1	67,0	1,7	1,6
G - 10	16	118,0	53,6	64,0	1,6	1,6	134,0	60,9	68,3	1,7	1,7
G - 11	17	120,0	54,5	64,0	1,6	1,6	142,0	64,5	69,0	1,8	1,8
G - 12	18	125,0	56,8	64,2	1,6	1,6	147,0	66,8	69,2	1,8	1,8

Based on the data in [Table G.1](#), the average body surface areas shown in [Table G.2](#) were selected for occupant's heat emission calculation.

Table G.2 — Average body surface area used in the calculations of occupant's heat emission

Building type	A_{DU} (m ²)
Detached house	1,70
Apartment building	1,70
Office building	1,70
Department store	1,70
Hotel	1,70
Restaurant	1,70
Sport, terminal, theatre	1,70
School	1,68
Day care centre (2 years old to 4 years old)	0,66
Kindergarten (5 years old to 6 years old)	0,77
Hospital	1,70
Meeting room	1,70
Classroom	1,70
Computer classroom	1,70

The heat emission of the body depends on the metabolic rate, and the energy release from the metabolism dependent on the muscular activity. Metabolism is measured in met units; 1 met is equivalent to 58,15 W/m² per body surface area. To determine dry and total heat losses of occupants in studied building categories, metabolic rate values shown in [Table G.3](#) were used.

Table G.3 — Metabolic rates of studied building categories [6][7][8][9]

Institution			Met
Day care centre	Children	2 years old to 4 years old	1,0
	Professional	Adult people	1,91
Kindergarten	Children	5 years old to 6 years old	1,39
School	Grade 1 to 6	7 years old to 12 years old	1,2
	Grade 7 to 12	13 years old to 18 years old	1,2
	Teacher	Adult people	1,46 t 1,72

Table G.3 (continued)

Institution		Met
Department store	Adult worker	1,6
Office, meeting room	Adult office worker (sedentary)	1,2
Detached house, apartment building	Adult people	1,2
Hotel, restaurant, hospital	Adult people (sedentary)	1,2
Sport, terminal, theatre	Adult people	1,6

The set point of indoor air temperature, mean radiant temperature, relative air velocity, and clothing insulation depends on season. Thus, the heat emission from the body are also varied. Table G.4 reports the range of interest of different parameters and the values used for summer and winter season calculation.

Table G.4 — Input parameters values for summer and winter occupant heat emission calculation

	Range	Summer	Winter
Temperature, °C	18 to 27	24,5	22,0
Mean radiant temperature, °C	18 to 27	24,5	22,0
Operative temperature, °C	18 to 27	24,5	22,0
Relative humidity, %	20 to 80	60,0	30,0
Clothing insulation, I_{cl}	0,3 to 1,4	0,6	1,0
Air velocity, m/s	0,05 to 0,2	0,15	0,1

The total heat loss from the occupant body is the sum of convection heat loss, radiation heat loss, vapour heat loss, sweat heat loss whereas dry heat loss is the sum of convection heat loss, and radiation heat loss from occupant. All formulas shown below are from Reference [10].

$$Q_{\text{convection}} = [f_{cl} h_c (t_{cl} - t_{op})] = 0,0014 M (34 - t_{op}) \tag{G.2}$$

$$Q_{\text{Radiation}} = 39,6 \cdot 10^{-9} A_{DU} f_{cl} \{ (t_{cl} + 273)^4 - (t_r + 273)^4 \} \tag{G.3}$$

$$Q_{\text{Vapor}} = A_{DU} \left[3,05 \cdot 10^{-3} \{ 5\,733 - 6,99(M - W) - P_{pw} \} + 1,72 \cdot 10^{-5} M (5\,867 - P_{pw}) \right] \tag{G.4}$$

$$\frac{t_{sk} - t_{cl}}{I_{cl}} = 3,96 \cdot 10^{-8} f_{cl} \left[(t_{cl} + 273)^4 - (t_r + 273)^4 \right] + f_{cl} h_c (t_{cl} - t_a) \tag{G.5}$$

$$h_c = \begin{cases} 2,38(t_{cl} - t_a)^{0,25} & \text{for } 2,38(t_{cl} - t_a)^{0,25} > 12,1\sqrt{V_{ar}} \\ 12,1\sqrt{V_{ar}} & \text{for } 2,38(t_{cl} - t_a)^{0,25} \leq 12,1\sqrt{V_{ar}} \end{cases} \tag{G.6}$$

$$f_{cl} = \begin{cases} 1,0 + 1,29I_{cl} & \text{for } I_{cl} < 0,078 \text{ m}^2\text{°C/W} \\ 1,05 + 0,645I_{cl} & \text{for } I_{cl} < 0,078 \text{ m}^2\text{°C/W} \end{cases} \tag{G.7}$$

$$t_{sk} = 35,7 - 0,028(M - W) \tag{G.8}$$

$$P_{ws} = \frac{e^{\left(77,345 0 + 0,005 7 T - \frac{7 235}{T}\right)}}{T^{8,2}} \quad (\text{G.9})$$

$$P_{pw} = \frac{RH}{P_{ws}} \times 100 \quad (\text{G.10})$$

$$Q_{\text{Total}} = A_{\text{DU}} \cdot M \quad (\text{G.11})$$

$$Q_{\text{Sweat}} = Q_{\text{Total}} - Q_{\text{Convection}} - Q_{\text{Radiation}} - Q_{\text{Vapour}} \quad (\text{G.12})$$

where

$Q_{\text{convection}}$ is convection heat loss, W;

$Q_{\text{Radiation}}$ is radiation heat loss, W;

Q_{Vapour} is vapour heat loss, W;

Q_{Total} is total heat loss, W;

Q_{Sweat} is heat loss through sweating, W;

A_{DU} is body surface area, m²;

M is metabolic rate, met;

W is external work, W;

t_a is air temperature, °C;

t_r is mean radiant temperature, °C;

t_{op} is operative temperature, °C;

t_{cl} is clothing surface temperature, °C;

t_{sk} is mean skin temperature, °C;

I_{cl} is clothing insulation. It is an average including uncovered parts of the body, $\frac{\text{m}^2 \cdot \text{°C}}{\text{W}}$;

f_{cl} is clothing area factor

h_c is convective heat transfer coefficient, $\frac{\text{W}}{\text{m}^2 \cdot \text{°C}}$;

P_{ws} is water vapour saturation pressure, Pa;

P_{pw} is partial water vapour pressure, Pa;

V_{ar} is relative mean air velocity, $\frac{\text{m}}{\text{s}}$;

RH is relative humidity, %.

Input parameters values in [Table G.4](#) are used to determine the heat loss from occupants during summer and winter. Components of heat emission from occupants during summer and winter are shown in [Table G.5](#) and [Table G.6](#), respectively.

Table G.5 — Occupancy heat loss components during summer

Building type	$Q_{\text{Convection}}$	$Q_{\text{Radiation}}$	Q_{Vapour}	Q_{Sweat}	Q_{Dry}	Q_{Total}
	W	W	W	W	W	W
Detached house	44,1	38,7	25,9	9,7	82,8	118,3
Apartment building	44,1	38,7	25,9	9,7	82,8	118,3
Office building	44,1	38,7	25,9	9,7	82,8	118,3
Department store	41,7	36,0	27,8	52,4	77,6	157,8
Hotel	44,1	38,7	25,9	9,7	82,8	118,3
Restaurant	44,1	38,7	25,9	9,7	82,8	118,3
Sport terminal, theatre	41,7	36,0	27,8	52,4	77,6	157,8
School	39,6	32,7	25,2	19,4	72,3	116,9
Day care centre (2 to 4 years old)	16,1	13,4	9,5	0,0	29,5	38,3
Kindergarten (5 to 6 years old)	17,6	14,4	11,9	18,1	32,0	62,1
Hospital	44,1	38,7	25,9	9,7	82,8	118,3
Meeting room	44,1	38,7	25,9	9,7	82,8	118,3
Classroom	44,1	38,7	25,9	9,7	82,8	118,3
Computer classroom	44,1	38,7	25,9	9,7	82,8	118,3

Table G.6 — Occupancy heat loss components during winter

Building type	$Q_{\text{Convection}}$	$Q_{\text{Radiation}}$	Q_{Vapour}	Q_{Sweat}	Q_{Dry}	Q_{Total}
	W	W	W	W	W	W
Detached house	38,3	39,5	33,4	7,1	77,8	118,3
Apartment building	38,3	39,5	33,4	7,1	77,8	118,3
Office building	38,3	39,5	33,4	7,1	77,8	118,3
Department store	36,9	37,3	35,9	47,6	74,2	157,8
Hotel	38,3	39,5	33,4	7,1	77,8	118,3
Restaurant	38,3	39,5	33,4	7,1	77,8	118,3
Sport, terminal, theatre	36,9	37,3	35,9	47,6	74,2	157,8
School	37,8	38,9	32,9	7,2	76,7	116,9
Day care centre (2 to 4 years old)	15,1	15,8	12,5	0,0	30,9	38,3
Kindergarten (5 to 6 years old)	17,1	17,4	15,7	11,9	34,5	62,1
Hospital	38,3	39,5	33,4	7,1	77,8	118,3
Meeting room	38,3	39,5	33,4	7,1	77,8	118,3
Classroom	38,3	39,5	33,4	7,1	77,8	118,3
Computer classroom	38,3	39,5	33,4	7,1	77,8	118,3

The simplification form of [Table G.5](#) and [G.6](#) are shown in [Table G.7](#). It shows the average dry and total heat loss from occupants.

Table G.7 — Summary of dry and total heat loss from occupant body

Building type	Metabolic rate, M	Body surface area, A_{DU}	Summer		Winter		Average	
			Q_{Dry}	Q_{Total}	Q_{Dry}	Q_{Total}	Q_{Dry}	Q_{Total}
	met	m ²	C	W	W	W	W	W
Detached house	1,2	1,70	82,8	118,3	77,8	118,3	80,3	118,3
Apartment building	1,2	1,70	82,8	118,3	77,8	118,3	80,3	118,3
Office building	1,2	1,70	82,8	118,3	77,8	118,3	80,3	118,3
Departmental store	1,6	1,70	77,6	157,8	74,2	157,8	75,9	157,8
Hotel	1,2	1,70	82,8	118,3	77,8	118,3	80,3	118,3
Restaurant	1,2	1,70	82,8	118,3	77,8	118,3	80,3	118,3
Terminal, sport hall	1,6	1,70	77,6	157,8	74,2	157,8	75,9	157,8
School	1,2	1,68	72,3	116,9	76,7	116,9	74,5	116,9
Day care centre (2 to 4 years old)	1,0	0,66	29,5	38,3	30,9	38,3	30,2	38,3
Kindergarten (5 to 6 years old)	1,39	0,77	32,0	62,1	34,5	62,1	33,2	62,1
Hospital	1,2	1,70	82,8	118,3	77,8	118,3	80,3	118,3
Meeting room	1,2	1,70	82,8	118,3	77,8	118,3	80,3	118,3
Classroom	1,2	1,70	82,8	118,3	77,8	118,3	80,3	118,3
Computer-classroom	1,2	1,70	82,8	118,3	77,8	118,3	80,3	118,3

Among all parameters, metabolic rate and body surface area are the most significant ones. In specific cases default values of metabolic rate can be misleading. For instance, the metabolic rate of occupants in a sport hall can vary from 1,5 met to 10,0 met⁹. Thus, in such cases, it is important to specify the occupant activity in respective buildings before determining the dry and total heat loss from occupant body.

Annex H (informative)

Long-term evaluation of the general thermal comfort conditions

To evaluate the comfort conditions over time (season, year), a summation of parameters can 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.

- a) The weighing factor, W_f , 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. $23,0\text{ °C} < \theta_o \leq 26,0\text{ °C}$ corresponding to $-0,5 < PMV < 0,5$ as specified in [Annex B](#) for single offices, category II, summer).

- b) The weighing factor, w_f , is calculated as

$$w_f = \theta_o - \theta_{o,limit}$$

when $\theta_o < \theta_{o,limit,lower}$ or $\theta_{o,limit,upper} < \theta_o$

- c) 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:

$$\Sigma w_f \cdot \text{time} \quad \text{for } \theta_o > \theta_{o,limit,upper}$$

Cold period:

$$\Sigma w_f \cdot \text{time} \quad \text{for } \theta_o < \theta_{o,limit,lower}$$

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:

- a) The weighing factor, w_f , equals 0 for:

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

where PMV_{limit} is determined by the comfort range specified according to [Annex B](#).

- b) The weighing factor, w_f , is calculated as:

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

where

$PMV < PMV_{\text{limit,lower}}$ or $PMV_{\text{limit,upper}} < PMV$, in which:

$PPD_{\text{actualPMV}}$ is the PPD corresponding to the actual PMV;

PPD_{PMVlimit} is the PPD corresponding to PMV_{limit} .

- c) 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:

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

Cold period:

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

[Table H.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 °C to 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 can be used for the evaluation of long-term comfort conditions.

Table H.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		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	
	25	0	0
	26	0	0
Warm	27	1	1,9
	28	2	3,1
	29	3	4,7

Annex I (informative)

Recommended criteria for acceptable deviations

I.1 Indoor environmental quality category

To require that the conditions are within a given category 100 % of the time will often result in too large building systems, which most of the year will operate at a low efficiency. Therefore, a certain deviation part of the year should be accepted. The length and/or level of such an exceedance should be listed in the design documents. This could be specified as an allowable length of time in a lower category than the design category.

The selection of a category is mainly important for the input values to the design. The categories can also be used to show the yearly performance of a space or building.

Examples of methods to evaluate long-term performance of building are given in [Annex D](#).

I.2 Length of deviation

[Table I.1](#) show examples which correspond to a % deviation based on working hours.

Table I.1 — Examples of length of deviations corresponding to a certain % of occupied hours

x% / y% of period	Weekly hours		Monthly hours		Yearly hours	
	20 %	50 %	12 %	25 %	3 %	6 %
Working time	8	20	21	44	63	126
Total hours	40		175		2 100	
Total time	33	58	86	180	259	518
Total hours	166		720		8 640	

This allows for short time deviations, e.g. when opening windows, where short time increased air velocity and noise will be accepted. For example, it is allowed on the 6 % level to have temperatures above the criteria for 126 h during a year but not more than 20 h during a working week and 44 h during a working month. There should be a reasonable relation between deviations on annual, monthly and weekly basis.

By using more than one criteria (e.g. both annually and weekly), it is possible to e.g. set an indirect criteria for how long consecutive periods of increased or reduced temperatures can be accepted. A strict weekly requirement will mean that week-long periods of overheating or undercooling cannot be accepted, while a little overheating or undercooling is acceptable if it is evenly distributed over the year.

Example of relation between annual, monthly and weekly evaluation

The example is based on hourly measurements of temperature of a residential building in France with natural ventilation and ventilative cooling.

By applying 6 % criteria for the annual exceedance, the annual category is then category II, as at least 94 % of the hours are within category II (only 78 % of the hours are in category I, so it is clearly not a category I building).