eXTENDing the energy performance assessment and certification schemes via a mOdular approach

Comfort Operational Rating Procedure (CORP)

User-guide

(beta version 1.2)

2021

This document describes Comfort Operational Rating Procedure (CORP)

Beta Version 1.2, dated 26.08.2021

This version is applicable to new and existing residential, office and school buildings that are occupied.

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INTRODUCTION

Considering that people spend approximately 90% of their time indoors (residences, schools, offices, etc.), the indoor environment has a significant effect on people's, health, comfort and wellbeing. Thermal comfort, indoor air quality (IAQ), visual and acoustic comfort are the main determinants of the indoor environmental quality (IEQ) and constitute a vital driver in ensuring the quality of life and overall wellbeing of building occupants.

Although ensuring adequate levels of indoor air quality, thermal comfort, lighting and acoustics within buildings are among the most essential drivers for renovation, these aspects are rarely covered in Energy Performance Certificates (EPCs). In order not to compromise health and wellbeing of building occupants, renovation recommendations should go hand by hand with IEQ aspects. Energy efficiency and IEQ improvements are inter-related and can be both simultaneously achieved. EPCs are an integral part of the EPBD and are among the most important sources of information of the energy performance of the EU's building stock and have a great potential to further keep track of the overall IEQ.

The X-tendo project is developing a framework of 10 'next-generation EPC features' that aim at improving the usability, reliability and compliance of EPCs. One of these features is the 'comfort indicator' that would allow the assessment of building comfort levels in relation to indoor environmental quality, through reliable and evidence-based inputs. Evidence based IEQ inputs can originate from measurements, outcomes of occupant surveys, computer simulations and/or checklists. The development of the evaluation framework for the comfort indicator is based on four cross-cutting criteria: economic feasibility, compliance with international standards, quality and reliability and user-friendliness and is inspired by reliable frameworks and methods such as Level(s), Aldren project: TAIL index, etc.

The structure of this user-guide is comprised by five main chapters, the first one giving an overview of the Comfort Operational Rating Procedure (CORP) tool and other four, one for each indicator: (i) thermal comfort, (ii) indoor air quality, (iii) visual comfort and (iv) acoustics. Each chapter starts by giving an overview and general description of the indicator. The evaluation criteria for each indicator based on specified standards and methods are then presented. Each indicator consists of specific criteria describing a narrower area of evaluation of the indicator and within each criterion several parameters are found. For each parameter a single or multiple assessment protocols are then defined.

Scope of the user-guide

This user-guide describes the evaluation process covering Operational[1] rating of residential (single-family house, multi-family house, apartments) buildings schools and offices and is complemented by a CORP assessment tool (beta version) for each of the three building types

[1] Assessment for existing buildings (occupied)

which the assessor should fill in based on the guidelines listed in the presented in this user-guide.

This user-guide is developed to assist assessors to determine the comfort rating of a specific building using a representative space. It provides a list of the necessary requirements that need to be assessed in order to come up with a score for the evaluation of the four indicators of the building that is under assessment. The user-guide lists the required assessment protocol for each parameter within specified criteria of thermal comfort, indoor air quality, visual comfort and acoustic comfort indicators.

Using the assessment protocols given in this user-guide for the assessment of the indicators the tool gives outputs to rate the level of comfort in a building.

GENERAL PRINCIPLES

Operational Rating Procedure (CORP)

The comfort assessment of buildings is typically expressed as an operational rating when the building is occupied, and it is based on measurements, surveys and checklists under real status of occupancy. The method assumes that a building is occupied and used for more than a year that are newly constructed, renovated or existing. Operational rating may be granted with a higher validity in years. Operational rating records the actual comfort level of occupants over a course of period. Operational rating provides real information about how comfortable the buildings based on its use and operation.

Assessment approach for operational rating

The assessment approach for operational rating is based on measurements, surveys and checklists:

Measurements

On-site measurements are crucial to objectively evaluate the indoor environmental quality. Therefore, CORP incorporates few key measurements in the buildings for calculation of the comfort rating. The measurements are conducted based on standard protocols described in this document.

Measurements are conducted by the assessor, obligatory measurements of: Temperature, relative humidity, Carbon dioxide (ppm)

Surveys

Also, building occupants are the most important source of information regarding IEQ and its effects on their health, comfort and well-being. The development of the questions for the Post Occupancy Evaluation (POE) are based on standardised questionnaires such as the CBE and BUS surveys and are mainly investigating the levels of satisfaction and perception of the indoor environmental quality [1]. In the case of residences, the main occupier (person spending the most time inside the living room) should fill in the survey. For schools, the teacher teaching in the examined classroom and for offices the employee spending most of the time in a selected office should fill in the survey. Before handing the survey to the building occupants, the assessor should brief them on the scope of the assessment, the value of IEQ and should highlight the importance of their perception and satisfaction about the indoor environment. That information will also be described on the first and introductory page of the survey.

Surveys are filled in by the building occupant (during the assessor's visit onsite).

Checklists

Taking into account the fact that a great amount of information will not be captured through the selected measurement methodology and survey, it is important to include a checklists assessing additional information about the indoor environment. Checklists will be filled in by the expert issuing the EPC during the onsite visit for the building's inspection and installation of the monitoring equipment.

Checklists are filled in by the assessor during the onsite visit.

By combining the findings from (objective) measurements, information from checklists and user's (subjective) perception, satisfaction and preference, a clear, comprehensive and holistic profile of the indoor environmental quality and the comfort feature is created.

Building types and representative spaces

For CORP assessment, a representative space of the building should be selected that is generally occupied and used for a larger period. The CORP is valid if the assessment is carried out in the below identified representative spaces of buildings:

- Residences: For the case of dwellings, that space is the living room.
- Schools: For schools, it should be a classroom (<=50sqm or 20-25 student stations) that is frequently occupied at full occupancy round the year
- Offices: The representative office should be a typical office (<15sqm occupied by 1-2 persons) of that building, which is also frequently occupied for a large period of time at full occupancy round the year.

The exact location of the monitoring equipment is mentioned in each of the protocols.

Scoring and Weighting

Four main indicators will be assessed within the CORP: (i) thermal comfort, (ii) indoor air quality, (iii) visual comfort, and (iv) acoustic comfort. To identify the overall IEQ level, all four indicators will be assessed independently based on multiple criteria. Under each criterion, certain parameters must be assessed to achieve a required score (see Figure 1). A combined rating is possible to assess for all the indicators in the beta version and it is also possible to rate individual indicators as shown in Figure 1. By default, an equal weightage for all indicators is assumed.

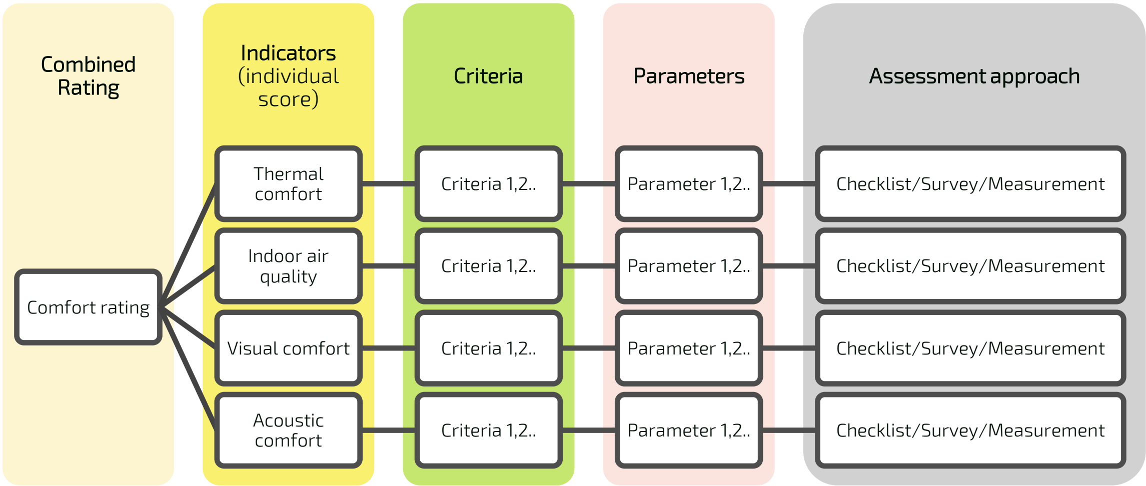

Figure 1: Structure of criteria and parameters for each indicator

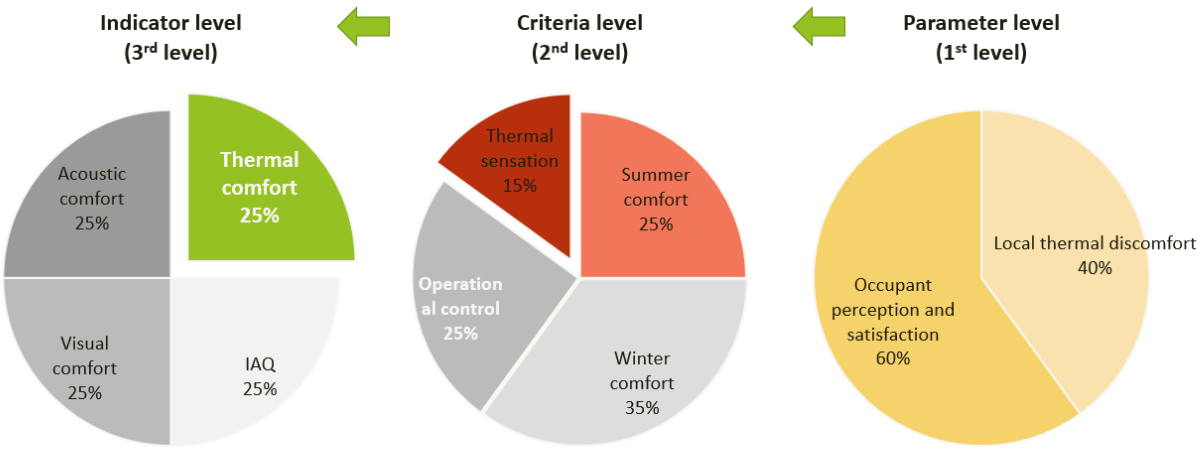

Figure 2: An example of two levels of weightage for the thermal comfort indicator

A description of the terms used and their explanation for the comfort feature assessment is given below (refer to Figure 1 and Figure 2):

a) **Indicators:** This refers to the four main components of the comfort feature. These components may be assigned equal or different relative weightage depending on the different aspects, e.g. region, type of buildings etc. Each indicator will be assessed based on several criteria.
b) **Criteria:** The criteria are the aspects that are assessed under each indicator. The list of criteria is prepared based on existing literature. Criteria will be assigned different or similar relative weightage.
c) **Parameters:** A list of parameters is used to assess each criterion based on the impact on comfort and health and well-being of the occupants. Relative weightage is assigned to each parameter based on expert inputs. Each parameter can obtain a score of 0 (worst) to 10 (best) which is assessed using different assessment methods

such as checklists, surveys or measurements. Individual scales for each parameter are developed for their scoring.

Throughout this user guide, several tables covering exceedance criteria, recommended limit values and deviations corresponding to certain percentages of occupied hours are given to explain the calculations used behind the estimation of scores.

1 OVERVIEW OF THE COMFORT OPERATIONAL RATING PROCEEDURE (CORP) TOOL

This guideline is accompanied by CORP beta versions for residential, office and school assessment. All the tabs in the CORP tool are highlighted in the guide in blue colour for quick referencing.

Information tab [INFO]

Legend for sheets

Comfort rating display

Individual Indicator Rating Display

Input data tabs

The 'INFO' tab includes a disclaimer of Comfort Operational Rating Procedure (CORP) and it briefly describes the legends of cells and tabs. In dark blue and yellow are the tabs in which results are displayed (no inputs data are required) whereas grey tabs are input data tabs, that the user needs to complete.

Legend for cells

0	*User-input cells*
0%	*Weights*
Cell	*Linked cells to calculation tabs*
0	*Calculated outputs*

Regarding the legends for cells, in light yellow are input cells that are found in the grey tabs which are required to be filled in by the assessor.

Turquoise cells are found in the comfort rating display that represent the individual indicator weights that should be filled in by the assessor (default weights are assumed to be 25% for all indicators). However, the sum of weights of all selected indicators must be always 100%.

The orange underlined text found in cells of the yellow tabs, link the parameters to the respective assessment tabs, whereas the orange cells found in the yellow tabs represent the calculated outputs and scores of each parameter, based on the data inserted in the grey tabs.

Comfort rating display tab [Comfort Rating]

This tab gives the overall rating of comfort in the assessed zone. After assigning weights in each of the indicators (thermal comfort, indoor air quality, visual comfort and acoustic comfort), based on the inputs provided in each of the corresponding tabs, this tab visualises the achieved rating of comfort (Figure 3).

Figure 3: Visualized comfort rating

Yellow tabs

There are four yellow tabs, one for each indicator: thermal comfort, indoor air quality, visual comfort, acoustic comfort. Each of these tabs presents an overview of the individual rating per indicator (see Figure 4), but also a breakdown of the individual scores of the specific parameters within each criterion. These are mainly output tabs; however, they give the option to the user to define weights for each of the criteria if necessary.

Score	3.3		Rating	Bad

Figure 4: Example individual score and rating of the indicator in yellow tabs

The user can select the parameter (underlined in orange) that needs to be evaluated by clicking on it, and it will automatically guide him/her to the relevant tab that needs to be completed.

Grey tabs

The inputs required for the calculation of scoring of each individual indicator should be filled in the grey tabs. The table below indicates the grey input tabs that correspond to each of the yellow indicator tabs:

Thermal_Comfort (TC)	TC_IAQ_Measurement TC_Survey TC_Checklist
Indoor_Air_Quality (IAQ)	TC_IAQ_Measurement IAQ_Checklist IAQ_Calculation

	IAQ_Survey
Visual_Comfort (VC)	VC_Measurement VC_Survey VC_Checklist
Acoustic_Comfort (AC)	AC_Checklist AC_Survey

2 THERMAL COMFORT INDICATOR [Thermal_comfort (TC)]

Based on the definition of EN ISO 7730, 'thermal comfort is that condition of mind which expresses satisfaction with the thermal environment' [2]. The thermal environment is defined by several environmental parameters such as temperature (air, radiant), relative humidity, personal parameters such as clothing, level of activity, gender and age (parameters that affect metabolic rate) [3].

Criteria, parameter definitions and assessment protocols

The methods to evaluate the thermal comfort indicator are defined under 4 criteria and 9 indicators as shown in Figure 5.

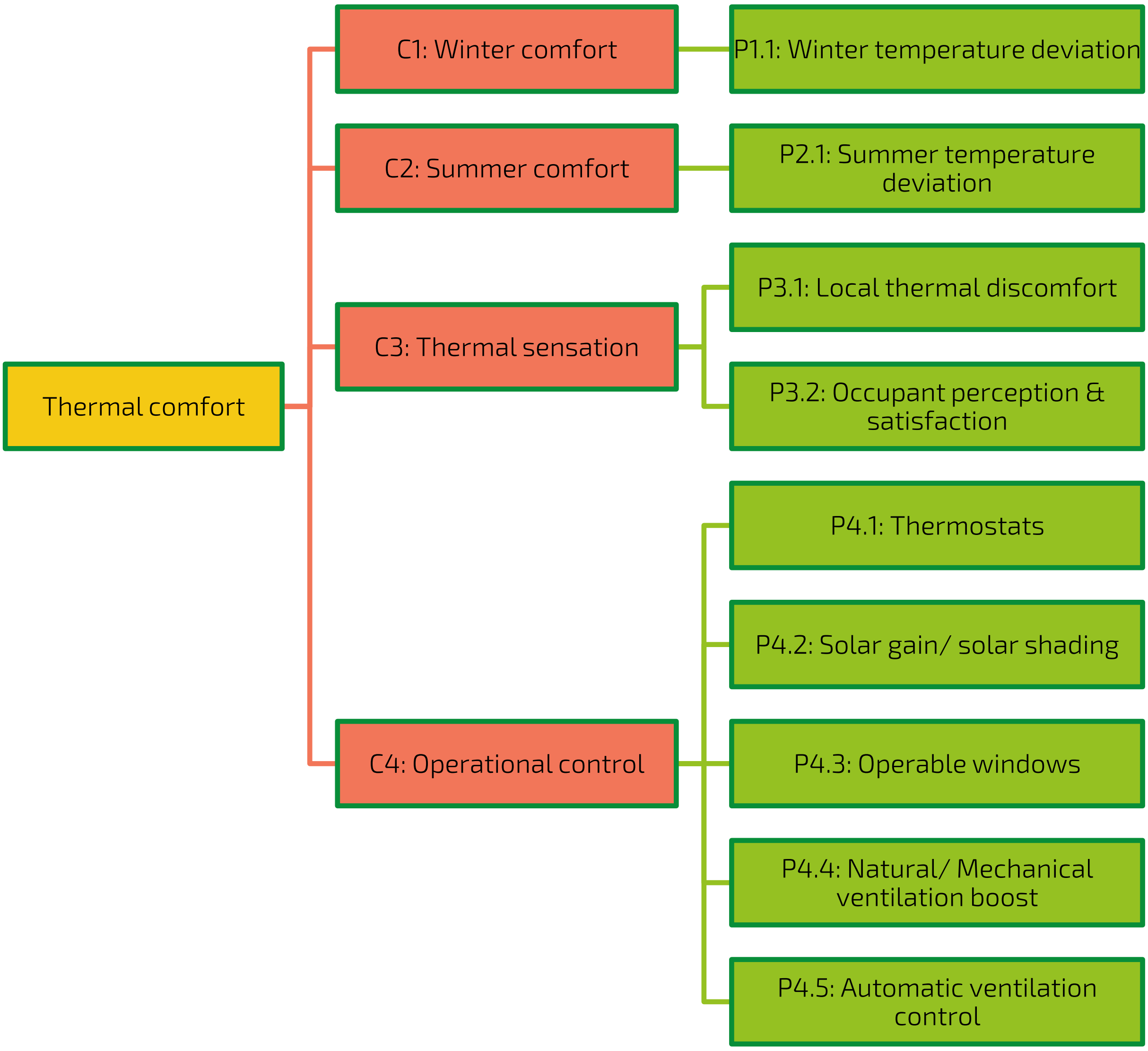

Figure 5: Criteria and parameters for thermal comfort indicator

CRITERION 1: Winter comfort [TC_IAQ_Measurement]

Parameter 1.1: Winter temperature deviation

The EN 16798-2:2019 (Annex-E) [10] specifies a method for evaluation of annual operative air temperatures in terms of percentage outside the comfort ranges. Since the operative temperature is assumed to be equal to indoor air temperature in this assessment [8][9], therefore, the indoor air temperature limits are based on the EN 16798-2:2019 in Table 1. These criteria can be used for thermal comfort assessment in winters for buildings with or without mechanical cooling systems.

Table 1: Recommended minimum temperature for winter comfort for buildings with or without mechanical cooling systems

Type of building or space	Category	indoor air temperature range [°C]	indoor air temperature range [°C]
		Mechanically conditioned spaces	Non-conditioned spaces
Residential buildings (living rooms)	I	21.0 - 25.0	21.0 - 25.0
	II	20.0 - 25.0	20.0 - 25.0
	III	18.0 - 25.0	18.0 - 25.0
	IV	17.0 - 25.0	17.0 - 25.0
Offices and Schools (single offices, class rooms)	I	21.0 – 23.0	21.0 – 23.0
	II	20.0 – 24.0	20.0 – 24.0
	III	19.0 – 25.0	19.0 – 25.0
	IV	17.0 – 26.0	17.0 – 26.0
NOTES: Criteria apply with **sedentary activity ~1.2 met** and **clothing ~1.0 clo.** The minimum indoor temperature limits apply when t_{rm} =<12°C.			

For calculation of winter temperature deviation indoor air temperature must be recorded in representative spaces of residential/office and school buildings using the details below:

Indoor air temperature

Following the details of the protocol listed in Table 2 the on-site monitoring of indoor air temperature will be conducted in winters.

Table 2: Details for indoor air temperature measurements (winters)

Duration	Location	Instrument		
		Time-step (minimum)	Measurement range	Accuracy
Week	1m inward from the walls, windows or centre of the room.	5min or less	10°C to 40°C	±0.2°C

	0.6m (seated occupants) 1.1m (standing occupant)			

Calculation of exceedance hours for winter temperature deviation

Indoor temperature data from measurements in hourly time-step should be copied in the corresponding cells of column E of the [TC_IAQ_measurement] tab. External temperature data of the same logging interval (hourly time step) can be collected from the nearest/local weather station and should be also copied in column D.

The tool will calculate the percentage of hours during the hours the representative is occupied when then indoor air temperature is outside the range listed in Table 1. Following the deviation benchmarks given in Table 3 the category of the building is identified based on the criteria given in Table 4 and will be shown in cell D18 of the [Thermal_Comfort (TC)] tab. These criteria are applicable to residential, school and offices. In Table 4, exceedance criteria are given for weekly, monthly, and yearly measurements and will be automatically applied according to the dataset from the monitoring period added in [TC_IAQ_measurement] tab.

Measurement duration should be at least one week during winter. Measurements should be done under typical winter conditions (e.g. Dec, Jan, Feb).

Table 3: Examples of length deviations corresponding to a certain percentage of occupied hours (if no national criteria is available)

x% of period	Weekly hours	Monthly hours	Yearly hours
	20%	12%	5%
Working time	*8*	*21*	*105*
Total hours	40	175	2100
Total time	*33*	*86*	*432*
Total hours	166	720	8640

Table 4: Exceedance criteria for winter indoor air temperature

Category	Hours criteria to assign thermal comfort category		
Residential/School/Office	*Weekly*	*Monthly*	*Yearly*
I	≥ 80%	≥ 88%	≥ 95%
II	≥ 80%	≥ 88%	≥ 95%
III	≥ 80%	≥ 88%	≥ 95%
IV	≥ 80%	≥ 88%	≥ 95%

Out of category (all values outside above categories)			

CRITERION 2: Summer comfort [TC_IAQ_Measurement]

Parameter 1.4: Summer temperature deviation

Summer comfort can be evaluated by calculating the % deviation of indoor air temperatures in a building space that is mechanically conditioned, based on measurements. For conditioned spaces the fixed values given in Table 5 are applied.

However, for non-conditioned/ naturally ventilated buildings, the adaptive comfort model is applicable [2], [5] to determine the comfort temperature limits that allow for the occupants to adapt to the surrounding environment by three means: physiological (acclimatisation), behavioural (changing activity, clothing level, opening/closing windows) and psychological (cognitive, social and cultural variables) [11]. Acceptable indoor temperatures without mechanical heating or cooling are calculated based on indoor air temperature and outdoor air temperature while considering the adaptation occupants.

The indoor air temperature ranges for summer ($t_{i\,min}$ / $t_{i\,max}$) given in Table 5 are calculated using outdoor running mean temperature (t_{rm}) obtained using the outdoor air temperature (t_{ed}) determining the comfort ranges that are cross-evaluated based on categories defined in EN 16798-1 [6]. Daily mean outdoor air temperature for previous day obtained from measurements or the nearby meteorological station. The method for calculation of running mean outdoor air temperatures is given below.

Calculation of running mean outdoor air temperatures

To calculate the adaptive comfort ranges during summer, the indoor air temperature (instead of operative temperature) are predicted based on a function of the exponentially weighted running mean of the outdoor temperature [12]. The exponentially weighted outside running mean temperature accounts for time-dependency over which the occupants adapt to their environment and is calculated based on equations (1) and (2) below:

$$t_{rm} = (1-\alpha)t_{ed-1} + \alpha t_{rm-1} \quad (1)$$

$$t_{rm} = \frac{t_{ed-1}+0.8t_{ed-2}+0.6t_{ed-3}+0.5t_{ed-4}+0.4t_{ed-5}+0.3t_{ed-6}+0.2t_{ed-7}}{3.8} \quad (2)$$

where

- t_{rm} the running mean indoor air temperature for today
- t_{rm-1} the running mean indoor air temperature for the previous day
- t_{ed-1} the daily mean external temperature for the previous day
- t_{ed-2} the daily mean external temperature for the day before (and so on)
- α a constant between 0 and 1 (recommended as 0.8 for use if the running means are calculated weekly)

Indoor air temperature limits for evaluating summer comfort for different types of buildings or spaces for conditioned and non-conditioned spaces are given in Table 14.

Table 5: Indoor air temperature limits for summer comfort

Type of building or space	Category	Indoor air temperature range [°C]	Indoor air temperature range for summer and shoulder seasons [°C]
		Conditioned spaces	Non- conditioned spaces
Residential buildings (living rooms)	I	23.5 - 25.5	$t_{i\,min/max} = 0.33t_{rm} \pm 20.8$
	II	23.0 - 26.0	$t_{i\,min/max} = 0.33t_{rm} \pm 21.8$
	III	22.0 - 27.0	$t_{i\,min/max} = 0.33t_{rm} \pm 22.8$
	IV	21.0 - 28.0	Not recommended
Offices and Schools (single offices, classrooms)	I	23.5 - 25.5	$t_{i\,min/max} = 0.33t_{rm} \pm 20.8$
	II	23.0 - 26.0	$t_{i\,min/max} = 0.33t_{rm} \pm 21.8$
	III	22.0 - 27.0	$t_{i\,min/max} = 0.33t_{rm} \pm 22.8$
	IV	21.0 - 28.0	Not recommended
NOTES: Criteria apply with **sedentary activity ~1.2 met** and **clothing ~0.5 clo.** The maximum indoor temperature limits apply when t_{rm} =>12°C			

The adaptive comfort limits are applicable to the spaces when: (a) There is no mechanical cooling or heating system in operation; (b) Metabolic rates ranging from 1.0 to 1.3 met; (c) Occupants are allowed to freely adapt their clothing insulation.

For calculation of summer temperature deviation using adaptive comfort limits two sets of data is required:

- Indoor air temperature

Following the details of the protocol listed in Table 6 the on-site monitoring of indoor air temperature will be conducted in summer for residential/office and school buildings.

Table 6: Details for indoor air temperature measurements (summer)

Duration	Location	Instrument		
		Time-step (minimum)	Measurement range	Accuracy
Week	1m inward from the walls, windows or centre of the room. 0.6m (seated occupants)	5min or less	10°C to 40°C	±0.2°C

	1.1m (standing occupant)			

- Outdoor air temperature

Outdoor air temperature is required to calculate the outdoor running mean temperature that is used for the calculation of the indoor air temperature limits as specified in Table 5. The outdoor air temperature can obtained from the nearest available weather station.

Calculation of exceedance hours for summer temperature deviation

Calculate the number or percentage of hours during the hours the building is occupied, when the indoor air temperature is outside range listed in Table 5. The criteria presented in Table 7 is used to categorise the building based on hours of deviation considering the air temperature range given in Table 8.

Measurement duration should be at least a week. Measurements should be done both under (typical) summer conditions.

Table 7: Examples of length deviations corresponding to a certain percentage of occupied hours (if no national criteria is available)

x% of period	Weekly hours	Monthly hours	Yearly hours
	20%	12%	5%
Working time	*8*	*21*	*105*
Total hours	40	175	2100
Total time	*33*	*86*	*432*
Total hours	166	720	8640

Table 8: Exceedance criteria for summer indoor air temperature

Category	Hours criteria to assign thermal comfort category		
Residential/School/Office	*Weekly*	*Monthly*	*Yearly*
I	≥ 80%	≥ 88%	≥ 95%
II	≥ 80%	≥ 88%	≥ 95%
III	≥ 80%	≥ 88%	≥ 95%
IV	≥ 80%	≥ 88%	≥ 95%
Out of category (all values outside above categories)			

CRITERION 3: Thermal sensation [TC_Survey]

Parameter 3.1: Local thermal discomfort

Local thermal discomfort is caused by unwanted heating or cooling of a particular part of the body in conditioned spaces and it plays key role in determining the level of comfort indoors. This parameter is assessed subjectively with the occupants.

The local thermal discomfort aspects have been covered in the survey that will be conducted with the occupants.

The assessment of local thermal discomfort is conducted via occupant survey using a 5-point scale as given in Table 9 for residential, office and school buildings.

Table 9: Local thermal discomfort occupant survey for residential buildings (to be completed by the occupant)

How often do you experience the following in your space?					
Cold walls in winter	One or more times a day	One or more times a week	One or more times over a month	Less often	Never
Warm/Cold floor in winter					
Common condensation on windows (humidity)					
Draughts from windows/ doors/ attic (air movement)					
Temperature differences among rooms					
Temperature differences while standing and sitting					
Direct sunlight indoors in winter					
Convectors used in winter					

Refer to Annex I for surveys to be used for office and school buildings.

The assessor should fill in the answers of the interviewee in cells I6 to I13 of the [TC_survey] tab by selecting from a drop-down menu of the preselected answers.

Parameter 3.2: Occupant perception and satisfaction

Survey using 7-point scale given in Table 10 will be used to record the satisfaction of the occupant with their thermal environment in winter/summer.

Table 10: Occupant thermal satisfaction survey for residential/office/school buildings (to be completed by the occupant)

How satisfied are you with the overall temperature conditions of your space?							
In Summer In Winter	Very dissatisfied	Dissatisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Satisfied	Very satisfied

CRITERION 4: Operational control [TC_Checklist]

A criterion for occupant control is also included in the thermal comfort assessment. It covers the essential aspect of operational control of the buildings in the assessment that has been found to be effective in maintaining the satisfactory level of indoor comfort. Occupant behaviour is challenging to measure and predict. Evaluation of operational control will be done based on certain parameters assessed checklists.

Following a visual inspection, the assessor should select from the drop-down menus of the light-yellow cells of column K in tab [TC_Checklist].

Parameter 4.1: Thermostats

Thermostat exists in different forms across different building spaces. Therefore, the developed checklist in Table 11 is based on the flexibility and convenience of adjusting the thermostats. This parameter can be used for residential, office and school buildings.

Table 11: Checklist for thermostats (all building types)

Thermostats	No thermostat	Central thermostat (non-programmable)	Individual room control (non-programmable)	Central thermostat (programmable)	Individual room control (programmable)	Wi-Fi thermostat	Smart thermostat (self-learning)

Parameter 4.2: Solar shading

There are multiple types of shading or solar control devices in the building spaces. The checklist provided in Table 12 is based on the effectiveness in solar control devices in controlling the solar gain inside the space. This parameter can be used for residential, office and school buildings.

Table 12: Checklist for solar shading

Solar shading	No shading/No	Curtains (manual)	Curtains (automatic)	Internal blinds (manual)	Internal blinds (automatic)	External blinds (manual)/	External blinds (automatic)

	direct solar gain					fixed external shading	

Parameter 4.3 Operable windows

One of the major aspects of thermal regulation of building aspect is the occupant control and adjustment availability of windows in the building spaces. In Table 13, the checklist is prepared based on the effective open area that windows offer to the occupant for ventilation. This parameter can be used for residential, office and school buildings.

Table 13: Checklist of operable control of windows

Operable windows	No windows	Fixed windows	Top hung/ Double hung windows	Sliding windows	Pivoted windows	Casement/tilt and turn windows

Parameter 4.4: Natural ventilation boost

Especially during summers, the thermal comfort conditions are driven by natural ventilation possibilities inside the buildings. Therefore, in Table 14, a checklist is provided in the order to assess the effectiveness to boost the natural ventilation in the building spaces. This parameter can be used for residential, office and school buildings.

Table 14: Checklist for natural ventilation boost

Natural ventilation boost	No natural ventilation	Trickle ventilation	One sided window ventilation	Cross-ventilation (windows on opposite sides)	Passive stack ventilation (ventilation from roof and windows)

Parameter 4.5: Mechanical ventilation boost

Buildings with mechanical ventilation are more comfortable if they have options to regulate the mechanical ventilation in conditions when the occupancy is high or there is too much damp air inside. Table 15 provides a checklist for the assessment of the options available to boost the mechanical ventilation. This parameter can be used for residential, office and school buildings.

Table 15: Checklist of mechanical ventilation boost

Mechanical ventilation boost	Mechanical ventilation without boost	Ceiling/portable fans	High occupancy fresh air boost	Warm air/damp air boost present	Occupancy and warm/damp air boost present

Parameter 4.6: Automatic ventilation control

Buildings that have automatic ventilation control automatically adjust to the needs of occupants and have found to be effective in maintaining indoor thermal conditions inside the space. Table 16, provides a checklist assessing the presence of automatic ventilation systems. This parameter can be used for residential, office and school buildings.

Table 16: Checklist for automatic ventilation control

Automatic ventilation control	No	Yes	
Automatic windows and ventilators	Operator controlled	programmable	Sensor controlled
Automatic ventilation control	without demand control	with demand control	

3 INDOOR AIR QUALITY INDICATOR [Indoor_Air_Quality (IAQ)]

Acceptable indoor air quality refers to the indoor air that hasn't got harmful concentrations of contaminants with which most of the exposed building occupants are satisfied [13][3]. Source of contaminants in residential buildings are building occupants (CO_2 concentrations released from human respiration)activities such as cooking or smoking, indoor combustion sources, emissions from furnishings, cleaning products, construction materials [14]. The most common contaminants are carbon dioxide, carbon monoxide, particulate matter and volatile organic compounds (VOCs). Ventilation plays a critical role in removing contaminants from buildings and is crucial to ensure thermal comfort and good indoor air quality. However, introduction adequate levels of ventilation without addressing or removing indoor sources of air pollution (e.g. wood stoves, fireplaces etc.) may lead to a limited improvement in indoor air quality.

Criteria, parameter definitions and assessment protocols

There are many criteria that are measured to assess the indoor air quality of buildings. European countries have addressed the importance of indoor air quality by including legislation on indoor air contaminants [15]. The indoor air quality is assessed through a combination of 4 criteria and 9 parameters shown in Figure 6.

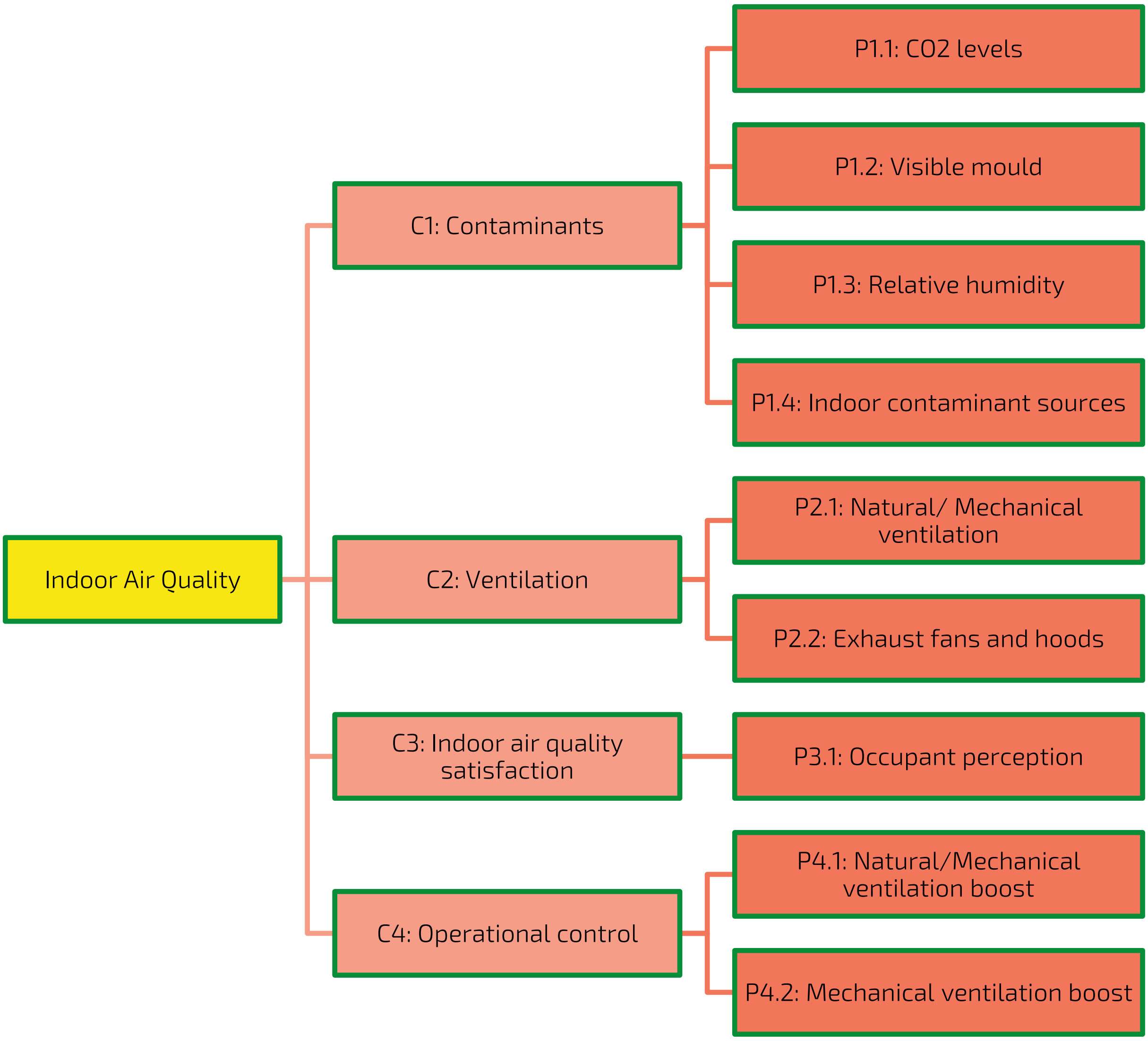

Figure 6: Criteria and parameters for Indoor Air Quality indicator

CRITERION 1: Contaminants

Parameter 1.1: CO_2 levels [TC_IAQ_Measurement]

The CO_2 concentration is considered an effective indicator of the rate of ventilation per occupant [16]. Since there are no other low-cost methods available for measuring the concentration of indoor pollutants, it is used as a reliable proxy for measuring indoor air quality (e.g. bio-effluents, pollutants from humans etc.) [17][12]. European standard EN 16798-2:2019 [63] defines the limits of concentration expected in different IEQ categories based on non-adapted occupancy requirements above outdoor concentration (default: 400ppm) assuming a standard CO_2 emission of 20 L/h/person. Air quality of building can be evaluated in buildings where people are the main pollution source by measuring the average CO_2 concentration in the building, when building is fully occupied. This can be done with representative samples of room air.

CO_2 measurements should preferably be made under winter conditions, as normally fresh air supply is lowest during the colder months (limited use of operable windows, partly closed façade 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. CO_2 concentrations recommended for different buildings types are given in Table 17

Table 17: CO_2 concentrations recommended for different category of buildings

Category *(Residential/Schools/Offices)*	Corresponding CO_2 concentration above outdoors in ppm
I	≤550
II	≤800
III	≤1350
IV	>1350
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 CO_2 emission is 20 l /h per person. Default outside concentration is assumed to be 400ppm.	

Following the details of the protocol listed in Table 18 the on-site monitoring of CO_2 will be conducted. Measured concentrations of CO_2 in hourly time-step should be copied in column F of the [TC_IAQ_Measurement] tab.

Table 18: Details of CO_2 measurements

Duration	Location	Instrument		
	For rooms with floor area <50m^2	Time-step (minimum)	Measurement range	Accuracy
Day/ Week/ Monthly/ Year	1-2m inward from the walls, windows or centre of the room. 1.1-1.2m height.	1 to 10 min	0 to +10000ppm	±(75ppm ±3% of measured value) (0 to +5000ppm)

Calculation of exceedance hours for CO_2 concentration

The tool calculates the percentage of hours during the time the building is occupied, when the CO_2 concentration is outside range listed in Table 17. The criteria presented in Table 19 is used to categorise the building based on hours of deviation considering the CO_2 concentration levels given in Table 20. Measurement duration should be at least a week. Measurements should be done under (typical) winter and (typical) summer conditions. The minimum requirements as specified in national codes must be followed if available.

Table 19: Examples of length deviations corresponding to a certain percentage of occupied hours (if no national criteria is available)

x% of period	Weekly hours	Monthly hours	Yearly hours
	20%	12%	5%
Working time	*8*	*21*	*105*
Total hours	40	175	2100
Total time	*33*	*86*	*432*
Total hours	166	720	8640

Table 20: Exceedance criteria for CO_2 concentration

Category	Hours criteria to assign IAQ category		
Residential/Schools/Offices	*Weekly*	*Monthly*	*Yearly*
I	≥ 80%	≥ 88%	≥ 95%
II	≥ 80%	≥ 88%	≥ 95%
III	≥ 80%	≥ 88%	≥ 95%
IV	≥ 80%	≥ 88%	≥ 95%

Parameter 1.2: Visible Mould [IAQ_Checklist]

High humidity or moisture content in the indoor air is a primary cause for the growth of mould inside the buildings. It gives rise to microbial pollution that involves hundreds of species of bacteria and fungi including mould that grow indoors when sufficient moisture is available [21]. Indoor moisture is more likely to occur in houses that are overcrowded, lack appropriate heating, poor ventilation, and lack of insulation. Exposure to microbial contaminants is clinically associated with respiratory symptoms, allergies, asthma and immunological reactions [22]. Mould have been found more common in less-affluent homes living under fuel poverty. Mould also occur in school buildings, day-care centres, offices and other buildings [21]. The areas affected inside a building could be easily detected by observing the patches on walls, floor or ceilings having visible mould growth.

Based on Level(s) framework [23] the checklist for mould visible mould assessment should be completed for residential/ office and school buildings in cell J4 of the [IAQ_Checklist] tab (Table 21).

Table 21: Checklist for mould inspection

Residential/offices/schools		Larger areas with visible mould (>=2500cm^2)	Damage with moderate area visible mould (<2500cm^2)	Moderate area visible mould (<2500cm^2)	Damage with minor area visible mould (<400cm^2)	Minor area visible mould (<400cm^2)	No visible mould

Parameter 1.3: Relative humidity levels [IAQ_Checklist]

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.). Excess humidity is responsible for indoor air contamination due to microbial growth. EN16798-1:2019 [6] defines the criteria for humidity based on comfort expectations and these are given in Table 22.

Table 22: Category of humidity levels defined for buildings based on EN 16798-1

Type of building or space	Category	Relative humidity [%]
Residential (living rooms)	I	30 - 50
	II	25 – 60
	III	20 - 70
	IV	Not recommended
Offices and Schools (single offices, classrooms)	I	30 - 50
	II	25 - 60
	III	20 - 70
	IV	Not recommended

Following the details of the protocol listed in Table 23 the on-site monitoring of RH will be conducted. Measured values in hourly time-step should be copied in column G of the [TC_IAQ_Measurement] tab.

Table 23: Details for relative humidity measurements

Duration	Location	Instrument		
		Time-step (minimum)	Measurement range	Accuracy
Week	1m inward from the walls, windows or centre of the room.	1 to 10 min	0 – 100%RH	2.05%RH typical (10 – 90%RH)

	0.6m (seated occupants) 1.1m (standing occupant)			

Calculation of exceedance hours for Relative humidity

The tool calculates the percentage of hours during the hours the building is occupied, when the relative humidity is outside the range listed in Table 22. The criteria presented in Table 24 is used to categorise the building based on hours of deviation considering the relative humidity range given in Table 25. Measurement duration should be at least a day, preferably a week.

Measurements should be done under (typical) summer and (typical) winter conditions. The minimum requirements as specified in national codes must be followed if available.

Table 24: Examples of length deviations corresponding to a certain percentage of occupied hours (if no national criteria is available)

x% of period	Weekly hours	Monthly hours	Yearly hours
	20%	12%	5%
Working time	*8*	*21*	*105*
Total hours	40	175	2100
Total time	*33*	*86*	*432*
Total hours	166	720	8640

Table 25: Exceedance criteria for relative humidity

Category	Hours criteria to assign humidity comfort category		
Residential/School/Office	*Weekly*	*Monthly*	*Yearly*
I	≥ 80%	≥ 88%	≥ 95%
II	≥ 80%	≥ 88%	≥ 95%
III	≥ 80%	≥ 88%	≥ 95%
IV	≥ 80%	≥ 88%	≥ 95%

Parameter 1.4: Indoor contaminant sources [IAQ_Checklist]

In residential buildings, some indoor sources that increase the contaminant levels are cooktops, fireplaces, portable heater etc. A survey and checklist is used to assess the presence of these sources and include in evaluation of the criterion. For residential buildings, the assessor should ask the occupants and fill in the survey given in Table 26 (cells J7 to J13 of the [IAQ_Checklist] tab). The assessor should also complete the checklist given in Table 27 (cells J17 to J21 of the [IAQ_Checklist] tab) by selecting from the drop-down menus.

Table 26: Survey for indoor contaminant sources in living room (to be completed by occupants)

Drying clothes indoors	Daily	3-4 times a week	1-2 times a week	Bi-weekly	Once a month/Never
Cooking (open kitchens)					
Fitness activities (aerobics, strength etc.)					
Cleaning disinfectants					
Lighting candles/incense					
Use of air fresheners					
Smoking					

Table 27: Checklist for indoor contaminant sources (to be completed by assessor)

Cooking stove	Solid fuel	Gas	Modular cook top (gas and electric)	Electrical coil cool top	Electric smooth cook top	Induction
Heating stove	Solid fuel	Gas	Electric			
Unvented stove	Yes	No				
Fireplace (operational)	Yes	No				
Portable heater	Yes	No				

Survey and checklist to be used for office and school buildings are provided in Annex I.

CRITERION 2: Ventilation [IAQ_Calculation]

Table 28 from EN 16798-1 provides a direct corelation of the required air flow rates with measured CO_2 concentration in building spaces. The level of CO_2 concentration is used as an indicator of measuring the ventilation rate [16]. Therefore, based on the assessment conducted in Criterion 1: Contaminants (Parameter 1.1) the reference in Table 28 is used for corresponding airflow rate for evaluation of Parameter 2.1 and 2.2 in this section. Due to health reasons the total minimum airflow rate during occupancy expressed as l/s per person should never be below 4 l/s per person (WHO).

Table 28: Corresponding air flow rates to CO_2 concentration

Category (Residential/School/Office)	Corresponding CO_2 concentration above outdoors in PPM for non-adapted persons*	Corresponding air flow rate# (l/s per person) - A_f	Corresponding ventilation rate (ach)
I	≤550	≥10	$V_r = \frac{A_f \times N \times 3.6}{V}$
II	≤800	≥7	
III	≤1350	≥4	
IV	≥1350	≤4	
NOTE: #when major contribution to emissions is by people *applicable to living rooms			*V*= Volume of the room A_f= Air flow rate *N*= No. of persons

Based on the main ventilation strategy the entries should be done either under natural ventilation or mechanical ventilation.

Parameter 2.1: Natural/Mechanical ventilation [IAQ_Calculation]

Natural ventilation

To maintain an adequate level of indoor air quality, natural ventilation should be possible in the spaces being assessed in naturally ventilated buildings. Often natural ventilation is provided through windows and window grilles, supply/extract grilles, stack ducts etc. Fresh air reduces the air contamination levels significantly. Building spaces must be evaluated for their capacity to provide natural ventilation, especially during winters. As there is direct corelation of CO_2 and air flow rates. Table 28 is used for scoring this parameter for naturally ventilated buildings. This parameter can be used for residential, office and school buildings.

The assessor should define the room volume (in cell D5) and the number of people anticipated to occupy the selected room (cell D6).

Mechanical ventilation

The commissioned or installation values of the mechanical ventilation system for the building spaces are compared with the values corresponding to ventilation requirements given in Table 28, where the calculation for the corresponding ventilation rate (ach) can also be determined using the volume and number of people in the representative room.

The assessor should define the room volume (in cell D5) and the number of people anticipated to occupy the selected room (cell D6).

The average mechanical ventilation rate of the room should be specified based on the installation specifications from the supplier.

Parameter 2.2: Exhaust fans/hoods

This parameter is evaluated only for residential buildings. Residential ventilation needs differ for different rooms and it impacts the level of ventilation in living rooms. Kitchen/ bathrooms must be equipped with ventilation boost to reduce the levels of indoor air pollution created due to sources such as cooking, bathing products etc. The minimum exhaust air flow for toilets, bathrooms and kitchens should be 35, 50 and 70 m^3/h, according to category II of EN16798-1. However, for the assessment of this parameter only the presence of exhaust is taken into account based on the checklist given in Table 29. The assessment of the exhaust fans and hoods is based on checklists and the assessor should fill in the light-yellow cells I19 to I22 in the [IAQ_Calculation] tab.

Table 29: Checklist for exhausts

Kitchen hood/exhaust	No		Manual switch	Automatic with manual override
Bathroom exhaust	No		Manual switch	Automatic with manual override
Toilet exhaust	No	Yes		
Utility exhaust	No	Yes		

CRITERION 3: Indoor air quality satisfaction [IAQ_Survey]

This criterion captures the perception of occupants in the building about the level of indoor air quality.

Parameter 3.1: Occupant satisfaction

A survey will be conducted with the occupants to identify the level of comfort they have with indoor air quality. The survey can be used for residential, office and school buildings.

Table 30: Indoor Air Quality occupant satisfaction survey for all buildings to be completed by occupants

Overall, how do you experience the air in your home?					
In summer In winter	Very dissatisfied	Slightly dissatisfied	Neither satisfied nor d	Slightly satisfied	Very satisfied
How often do you experience the following problems?					
Unpleasant odour from inside Unpleasant odour from outside	One or more times a day	One or more times a week	One or more times over a month	Less often	Never

Damp/ moist air					
Dry air					

CRITERION 4: Operational control

The parameters used in this criterion are same as Thermal comfort indicator (criterion 4-parameter 4.4, 4.5, 4.6). The impact of ventilation actions through occupant control are both on indoor thermal comfort and reduction of contaminants in the indoor air. Therefore, the parameters presented in this section are scored like thermal comfort indicator. No inputs are required here as scores are automatically calculated based on the thermal comfort inputs.

4 VISUAL COMFORT INDICATOR [Visual_Comfort (VC)]

Adequate lighting in buildings should create a pleasant appearance of the space, allow building occupants move safely and conduct their visual tasks effectively and accurately [29][30]. Excessive brightness or glare from either solar or electric sources can be disruptive; therefore, appropriate lighting levels can be ensured by natural or/and artificial lighting.

Recent studies have shown that lighting affects mood and circadian rhythms (sleep-wake cycle) and can improve our performance and wellbeing. Natural light significantly influences the visual comfort, while well-being and motivation of people can be affected without sufficient exposure to natural lighting. Daylight exposure through windows has a significant positive effect on sleep quality as well. However, increased use of glazing can increase the heat losses of a building, therefore, a correct balance between thermal losses and daylight levels is needed.

Criteria, parameter definitions and assessment protocols

Three main criteria of visual comfort have been identified (i) Illuminance levels, (ii)Occupant perception and satisfaction and (iii) operational control (see Figure 7). Each of the criteria includes parameters that can be assessed through either measurements, surveys or checklists.

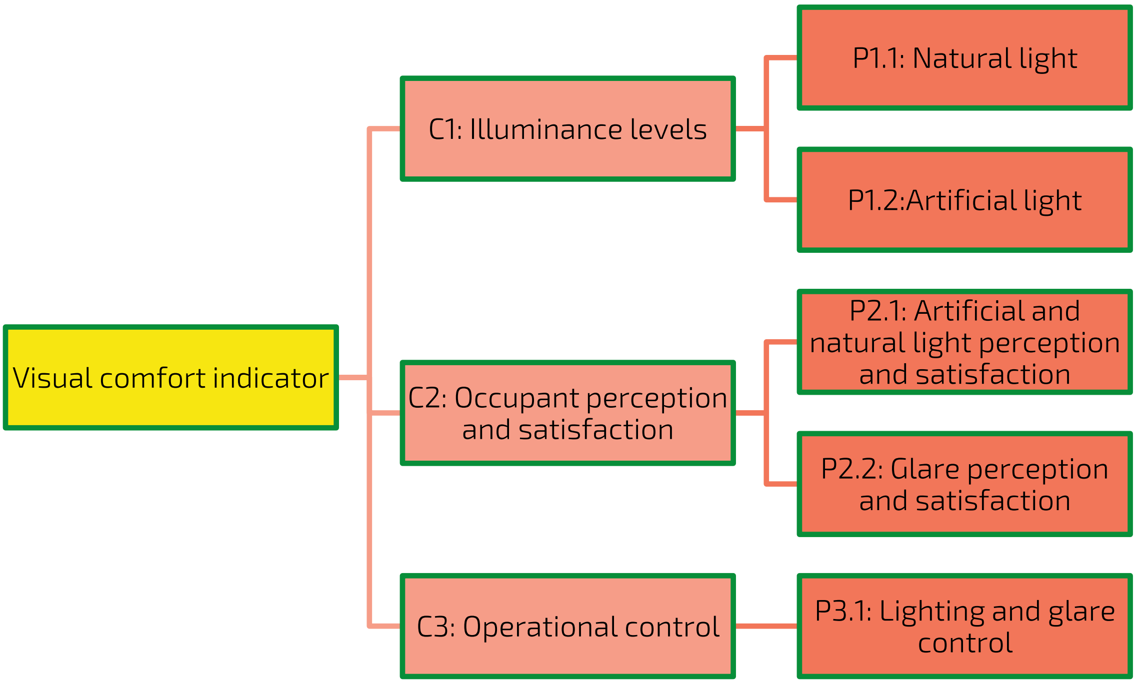

Figure 7: Structure of criteria and parameters within the visual comfort indicator

CRITERION 1: Illuminance levels

Illuminance is one of the main parameters that determine the luminous environment and represents the total amount of light delivered on a surface by either natural daylight or electrical fitting. Daylighting and artificial lighting must operate interactively. Exposure to adequate levels of natural light strengthens the alignment of our circadian rhythms and reduces dependence on electricity for artificial lighting [39].

Parameter 1.1: Natural light [VC_Measurement]

To evaluate the levels of natural light for CORP, the areas of windows per orientation within the representative space (e.g. living room for residences, single office or classroom) should be measured and filled in the Table 31 for parameter 1.1 given in tab: [VC_Measurment]. The effective floor area[2] of the room should be also inserted at the top of the same tab. The window to floor area ratio (WFR) is then estimated (in cell K18) and based on the categorization given in Table 32 'Category for residential buildings/offices/schools', a score for natural light is then estimated (cell L18).

Table 31: Table to enter window areas per orientation

ID	East (m^2)	West (m^2)	North (m^2)	South (m^2)
Window 1				
Window 2				
Window 3				
Window 4				
Window 5				
Window 6				
Window 7				
Window 8				
Window 9				
Window 10				
Total area				

[2] Effective floor area is measured by removing the area of an irregular part from the total area of the room

Table 32: Window to floor area ratio (WFR) classification for South, West and East facing facades (for all building types) [42]

Categories	Window to Floor Area Ratio (WFR) *Residential*	Window to Floor Area Ratio (WFR) *Office and School*
I	>20 and ≤30%*	>35 and ≤50%*
II	>10 and ≤20%	>20 and ≤35%
III	≥5 and ≤10%	≥10 and ≤20%
IV	<5%	<10%
Note: To avoid over lit spaces in buildings a maximum value is defined.		

Parameter 1.2: Artificial light [VC_Measurement]

Electric lighting should provide appropriate lighting level for all tasks performed in a space without causing glare or resulting to large variation between different surfaces of the space[43]. The artificial light parameter refers to the evaluation of the levels of artificial lighting within the space. Based on the classification given in Table 33 the scoring for artificial lighting levels will be conducted.

Table 33: Illuminance classification per building type (adapted from [36])

Category	Residences (Lux)	Schools (Lux)	Offices (Lux)
I	250 ≤ Illuminance < 500	500 ≤ Illuminance < 750	750 ≤ Illuminance < 1000
II	150 ≤ Illuminance <250	300 ≤ Illuminance < 500	500 ≤ Illuminance < 750
III	50 ≤ Illuminance < 150	no criteria	300 ≤ Illuminance < 500
IV	Illuminance < 50	Illuminance<300	Illuminance < 300

The availability of artificial lighting will be assessed based on the installed electric lighting systems. In case that information is not part of the EPC databases, the assessor should log the number of installed incandescent light bulbs and fluorescent/LED lamps and calculate the total lumens installed per room based on given Wattage in the table of parameter 1.2 of the [VC_Measurement] tab (Table 34). Illuminance is given by the total lumens per unit area (Cell K33).

Table 34: Checklist for the assessment of artificial lighting illuminance (to be completed by assessor) [44]

Incandescent light bulbs installed		Fluorescent/LED lamps		Lumens (lm)	Total Lumens (lm)
Count	Watt	Count	Watt		
	25		6.23	375	
	40		10	600	
	60		15	900	
	75		18.75	1125	
	100		25	1500	
	150		37.5	2250	
	200		50	3000	

CRITERION 2: Occupant perception and satisfaction

Parameter 2.1: Artificial and natural light perception and satisfaction [VC_Survey]

Building occupants' satisfaction in relation to the visual environment will be assessed through surveys. The questions are based on standardised questionnaires such as the CBE survey and are given for residential buildings in Table 35. The questions related to natural and artificial lighting perception and satisfaction are asked to the occupant by the assessor and selected in the drop-down lists on [VC_Survey] tab.

Table 35: Survey for natural and artificial light perception and satisfaction (residential buildings)

How do you perceive the artificial lighting quality in your living room?					
Very poor		Poor	Acceptable	Good	Very good
How do you perceive the daylight quality in your living room?					
In summer	Very poor	Poor	Acceptable	Good	Very good
In winter	Very poor	Poor	Acceptable	Good	Very good
How satisfied are you with the artificial lighting in your living room?					
Very dissatisfied		Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
How satisfied are you with the daylight quality in your living room?					
Very dissatisfied		Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very Satisfied

Survey for office and school buildings is given in Annex I.

Parameter 2.2: Glare perception and satisfaction [VC_Survey]

This parameter concerns the assessment of the visual environment in terms of glare from direct sunlight or lighting fixtures and the available measures to restrict that.

The assessment of this criterion will be done through findings collected from the surveys completed by the building occupants and the assessor enters them in the CORP tool. The questions of the survey related to glare perception and satisfaction are summarized in Table 36 below.

Table 36: Survey for glare perception and satisfaction (residential buildings)

How would you describe the glare in your living room? The question refers to all year round conditions.				
Too much	Much	Moderate	Little	None
Does artificial (e.g. reflections in tv screen) or natural light ever cause glare strong enough to bother you?				
Frequent	Sometimes	Occasional	Rare	Never
How satisfied are you with the visual comfort of the lighting in terms of glare, reflections and contrast?				
Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
Overall, does the lighting quality enhance or interferes with your comfort?				
Much interference	Some interference	Neither interferes nor enhances	Some enhancement	Much enhancement

Refer to Annex I for survey to be used in office and school buildings.

CRITERION 3: Operational control [VC_Checklist]

Parameter 3.1: Lighting and glare control

Lighting control refers to the control of brightness and lighting positions in a room through light adjustment or switching on/off. This parameter is partly evaluated through the surveys (Table 37) filled in by the building occupants, and partly by checklists (Table 38) filled in by the assessor. The survey and checklist can be used for residential/ office and school buildings. The assessor should fill in the light-yellow cells by selecting from the drop-down options of the [VC_Checklist] tab.

Table 37: Survey for lighting and glare control with occupants (for all building types)

Please rate your satisfaction with lighting controls in your normal work area (provisions of controls for blinds on windows or provision of dimming or controlling lighting equipment in the room)				
Very dissatisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied
Please rate your satisfaction with the access to daylight from your normal work area/ living room				
Very dissatisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied

Table 38: Checklist for shading (for all building types)

Availability of shading for lighting or glare control (for south facing windows)					
None	Adjustable work or activity area	Interior window shading e.g. shades, curtains, internal blinds)	Tinted/reflective/fritted glazing	External shading systems (e.g. external blinds, awning)	Variable opacity glazing e.g. electrochromic glass etc.
Availability of devices to control artificial lighting and glare					
None		Adjustable work or activity area	Task lighting	Adjustable lighting controls	Filter and diffusers

5 ACOUSTIC COMFORT INDICATOR [Acoustic_Comfort (AC)]

Acoustic comfort comprises the ability to protect building occupants from noise and provide a suitable acoustic environment to fulfil the purposes that the building is designed for [45]. Noise can cause annoyance, hearing damage or interference to speech intelligibility depending on its levels [31]. The acoustic quality of the built environment can be affected by different factors such as the buildings location, the city design, the building design the construction type and the material of construction elements. Road traffic, aircrafts, construction sites can generate increased levels of external noise, while background noise from HVAC systems or even noise from the neighbours can be disruptive [46]. The acoustic environment must be designed to avoid these harmful effects and the criteria used to specify an acceptable acoustic environment are expressed in sound levels decibels (dB), noise rating (NR) or noise criteria (NC) [47]. The World Health Organization (WHO) recommends a background noise level lower than 45 dB(A).

Criteria and parameter definitions and assessment protocols

To evaluate the acoustic environment, we have identified 3 main criteria, those of acoustic levels, occupant perception and satisfaction and operational control. Within acoustic levels there are the two parameters of indoor and outdoor noise, under occupant perception and satisfaction only one parameter is used to record occupant's satisfaction and within operational control noise adjustment possibilities are recorded.

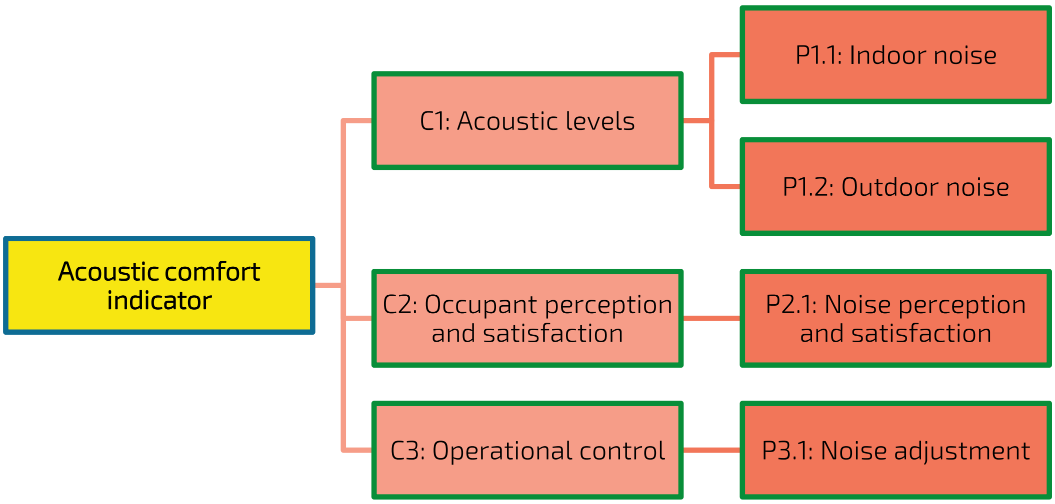

Figure 8: Criteria and parameters for acoustic comfort indicator

CRITERION 1: Noise levels

Indoor and outdoor acoustic levels shall be evaluated through surveys completed by building occupants and checklists completed by the assessor. The main objectives of the survey are to evaluate current levels of noise, assess outdoor noise exposure in their dwellings, identify sources of indoor and outdoor noise and assess the building occupants' perception and satisfaction of the overall acoustics environment.

Parameter 1.1: Indoor noise [AC_Checklist]

The main sources of indoor noise are home appliances, ventilation systems, home appliances and neighbours.

Considering that ventilation systems and technical installations are of the most important sources of noise indoors, the quickest way of evaluating these is through checklist .

Noise levels should be further examined based on additional information related e.g. to sound absorbing materials, collected through checklists shown in Table 40. Examples of sound absorbing materials are summarised in Table 39.

Table 39: Examples of sound absorbing materials for walls, floors and ceiling [36]

Walls	Rock-wool and Glass-wool- type sound absorbing materials etc.
Floors	Carpet, tatami matting etc.
Ceiling:	Rockwool glass-wool, gypsum board type sound absorbent ceiling material etc.

The assessor should complete the light-yellow cells by selecting the answers from the drop-down menu in the [AC_Checklist] tab.

Table 40: Sound operational control checklist (residential buildings)

Sound absorbing materials used in walls, floor, roof			
Not used	Used in 1 of the areas	Used in 2 of the areas	Used in all areas
Noise producing home appliances in the room (e.g. refrigerator, freezer etc.)			
No	Yes		
Is the room completely separated by doors, partitions etc. from other spaces?			
No	Yes		
Access to HVAC systems to adjust airflows			
No	Yes		
Does the HVC system have an adequate silencing system installed against noise from fans, ducts, machine vibrators etc.?			
No	Yes		

Refer to Annex I for office and school buildings checklist.

Parameter 1.2: Outdoor noise

Loud or repetitive outdoor noise can be risk factor for health outcomes, especially in urban areas. Individuals exposed to traffic noise have higher risk for diabetes, heart attack, and people exposed to aircraft and road traffic higher risk for hypertension. Comfort and well-being can be significantly improved when preventing excessive exterior noise [41]. Main sources of outdoor noise include road, rail, air traffic industries and construction work [49].

The noise sources that are in vicinity to the building should be identified and the building construction's characteristics will facilitate the evaluation of the outdoor noise. That information will be collected through checklists filled in by the assessor and by completing the light-yellow cells of the [AC_Checklist] tab of the Parameter 1.2.

Table 41: Checklist for outdoor noise levels (for all building types)

Please describe the noise sources that are in vicinity					
Airport	Railway/ construction-demolition works/industrial activity		Heavy traffic (main streets, highways)	Urban area (low traffic)	Quiet rural area
Please describe the building's construction (in relation to noise)					
Single glazing, no thermal insulation	Single glazing, thermal insulation	Single glazing, thermal insulation, sound-proofing insulation	Double glazing, no thermal insulation	Double glazing, thermal insulation	Double glazing, thermal and sound proofing insulation

CRITERION 2: Occupant perception and satisfaction

Parameter 2.1: Noise perception and satisfaction [AC_Survey]

Building occupants' perception and satisfaction in relation to the acoustic environment will be assessed through surveys (Table 42). The questions are based on standardised questionnaires such as the CBE survey [1]. The assessor should copy the answers provided by the building occupants in the corresponding light-yellow cells by selecting from the drop-down provided options in cells I5 to I23 of the [AC_Survey] tab.

Table 42: Survey for noise perception and satisfaction (residential buildings)

How do you perceive the acoustic environment in your living room?				
Very poor	Poor	Sufficient	Good	Very good

How satisfied are you with the overall noise level in the living room?				
Very satisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied
How satisfied are you with the internal sound transmission to the living room from adjacent rooms?				
Very satisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied
Have you experienced problems with noise from the neighbours in your apartment?				
Frequently	Sometimes	Occasional	Rare	Never
Have you experienced problems with noise inside your classroom, e.g. the ventilation system, HVAC, technical installation?				
Frequently	Sometimes	Occasional	Rare	Never
How satisfied are you with the outdoor noise level from the neighbourhood during the winter?				
Very satisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied
How satisfied are you with the outdoor noise level from the neighbourhood during the summer?				
Very satisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied

Refer to Annex I for office and school surveys.

CRITERION 3: Operational control

Occupant control of noise is of the main ways of defence against excessive noise exposure. This criterion assesses the extent to which building occupants are given this opportunity through either access to openable windows and HVAC or have taken the opportunity to install sound proofing materials.

Parameter 3.1: Noise adjustment [AC_Checklist]

The assessor will use the checklist in all types of buildings given in Table 43 to select the options available for noise adjustment.

Table 43: Sound operational control checklist (all types of buildings)

Openable windows towards silent side	
No	Yes
Flexibility to close internal doors	
No	Yes

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ANNEX I

Thermal comfort [Thermal_comfort (TC)]

CRITERION 3: Thermal sensation [TC_Survey]

Parameter 3.1: Local thermal discomfort

Table 44: Local thermal discomfort occupant survey for office buildings (to be completed by the occupant)

How often do you experience the following in your space?					
Cold walls in winter	One or more times a day	One or more times a week	One or more times over a month	Less often	Never
Warm/Cold floor in winter					
Common condensation on windows (humidity)					
Draughts from windows/ doors/ attic (air movement)					
Temperature differences among office rooms					
Temperature differences while standing and sitting					
Direct sunlight indoors in winter					
Convectors used in winter					

Table 45: Local thermal discomfort occupant survey for school buildings (to be completed by the occupant)

How often do you experience the following in your space?					
Cold walls in winter	One or more times a day	One or more times a week	One or more times over a month	Less often	Never
Warm/Cold floor in winter					
Common condensation on windows (humidity)					
Draughts from windows/ doors/ attic (air movement)					

Temperature differences among rooms					
Temperature differences while standing and sitting					
Direct sunlight indoors in winter					
Convectors used in winter					

Indoor Air Quality [Indoor_Air_Quality (IAQ)]

CRITERION 1: Contaminants [TC_Survey]

Parameter 1.4: Indoor contaminant sources [IAQ_Checklist]

Table 46: Survey for indoor contaminant sources in office buildings (to be completed by occupant)

Drying on radiators	Daily	3-4 times a week	1-2 times a week	Bi-weekly	Once a month/Never
Use hot water kettle					
Use printer/copying machine					
Use cleaning disinfectants					
Light candles/incense					
Use of air fresheners					
Smoking					

Table 47: Survey for indoor contaminant sources in classrooms (to be completed by teacher)

Eating activities (lunch, food breaks etc.)	Daily	3-4 times a week	1-2 times a week	Bi-weekly	Once a month/Never
Use teaching products (chalk, paints, art supplies etc.)					

Use printer/copying machine					
Use cleaning disinfectants					
Furnishings made of wood, plywood, fibre board					
Use of air fresheners					
Outdoor traffic intensity (vehicle emissions)					

Visual Comfort [Visual_Comfort (VC)]

CRITERION 2: Occupant perception and satisfaction [VC_Survey]

Parameter 2.1: Artificial and natural light perception and satisfaction

Table 48: Survey for natural and artificial light perception and satisfaction (office buildings)

How do you perceive the artificial lighting quality in your room?					
Very poor		Poor	Acceptable	Good	Very good
How do you perceive the daylight quality in your room?					
In summer	Very poor	Poor	Acceptable	Good	Very good
In winter	Very poor	Poor	Acceptable	Good	Very good
How satisfied are you with the artificial lighting in your room?					
Very dissatisfied		Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
How satisfied are you with the daylight quality in your room?					
Very dissatisfied		Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very Satisfied

Table 49: Survey for natural and artificial light perception and satisfaction (school buildings)

How do you perceive the artificial lighting quality in your classroom?					
Very poor		Poor	Acceptable	Good	Very good
How do you perceive the daylight quality in your classroom?					
In summer	Very poor	Poor	Acceptable	Good	Very good
In winter	Very poor	Poor	Acceptable	Good	Very good

How satisfied are you with the artificial lighting in your classroom?				
Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
How satisfied are you with the daylight quality in your classroom?				
Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very Satisfied

Parameter 2.2: Glare perception and satisfaction

Table 50: Survey for glare perception and satisfaction (office buildings)

How would you describe the glare in your normal work area? The question refers to all year round conditions.				
Too much	Much	Moderate	Little	None
Does artificial (e.g. reflections in computer screen for offices) or natural light ever cause glare strong enough to bother you?				
Frequent	Sometimes	Occasional	Rare	Never
How satisfied are you with the visual comfort of the lighting in terms of glare, reflections and contrast?				
Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
Overall, does the lighting quality enhance or interferes with your comfort?				
Much interference	Some interference	Neither interferes nor enhances	Some enhancement	Much enhancement

Table 51: Survey for glare perception and satisfaction (school buildings)

How would you describe the glare in your normal work area? The question refers to all year round conditions.				
Too much	Much	Moderate	Little	None
Does artificial (e.g. reflections on whiteboard) or natural light ever cause glare strong enough to bother you?				

Frequent	Sometimes	Occasional	Rare	Never
How satisfied are you with the visual comfort of the lighting in terms of glare, reflections and contrast in your classroom?				
Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
Overall, does the lighting quality enhance or interferes with your comfort?				
Much interference	Some interference	Neither interferes nor enhances	Some enhancement	Much enhancement

Acoustic Comfort [Acoustic_Comfort (AC)]

CRITERION 1: Noise levels

Parameter 1.1: Indoor noise [AC_Checklist]

Table 52: Sound operational control checklist (office buildings)

Sound absorbing materials used in walls, floor, roof			
Not used	Used in 1 of the areas	Used in 2 of the areas	Used in all areas
Noise producing appliances in the room (e.g. printer, refrigerator, freezer, kettle etc.)			
No	Yes		
Is the room completely separated by doors, partitions etc. from other spaces?			
No	Yes		
Access to HVAC systems to adjust airflows			
No	Yes		
Does the HVC system have an adequate silencing system installed against noise from fans, ducts, machine vibrators etc.?			
No	Yes		

Table 53: Sound operational control checklist (school buildings)

Sound absorbing materials used in walls, floor, roof			
Not used	Used in 1 of the areas	Used in 2 of the areas	Used in all areas
Noise producing appliances in the classroom (e.g. printer, copier etc.)			

No	Yes
Is the room completely separated by doors, partitions etc. from other spaces?	
No	Yes
Access to HVAC systems to adjust airflows	
No	Yes
Does the HVC system have an adequate silencing system installed against noise from fans, ducts, machine vibrators etc.?	
No	Yes

CRITERION 2: Occupant perception and satisfaction

Parameter 2.1: Noise perception and satisfaction [AC_Survey]

Table 54: Survey for noise perception and satisfaction (office buildings)

How do you perceive the acoustic environment in your room?				
Very poor	Poor	Sufficient	Good	Very good
How satisfied are you with the overall noise level in the room?				
Very satisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied
How satisfied are you with the internal sound transmission to the room from adjacent rooms?				
Very satisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied
Have you experienced problems with noise inside your room, e.g. the ventilation system, HVAC, technical installation?				
Frequently	Sometimes	Occasional	Rare	Never
How satisfied are you with the outdoor noise level during the winter?				
Very satisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied
How satisfied are you with the outdoor noise level during the summer?				
Very satisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied

Table 55: Survey for noise perception and satisfaction (school buildings)

How do you perceive the acoustic environment in your classroom?				
Very poor	Poor	Sufficient	Good	Very good
How satisfied are you with the overall noise level in the classroom?				
Very satisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied
How satisfied are you with the internal sound transmission to the classroom from adjacent rooms?				
Very satisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied
Have you experienced problems with noise inside your classroom, e.g. the ventilation system, HVAC, technical installation?				
Frequently	Sometimes	Occasional	Rare	Never
How satisfied are you with the outdoor noise level during the winter?				
Very satisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied
How satisfied are you with the outdoor noise level during the summer?				
Very satisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Very satisfied

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