Applications of the standard EN15251 for indoor environmental quality

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Introduction

Whatever we do in life, we like to have options and flexible choices and solutions. Why should everybody use the same criteria for design and operation of buildings? When we buy a car, when we buy a kitchen etc. we have choices and we can select lower or higher quality; but the car will still bring us from location A to location B and we can still cook food in the kitchen. This is now also possible in the discussion between a client and the consultant (architect, engineer). In the design phase it is possible to show the client the impact of different categories (energy use, equipment size, investment and running costs, to some extend also performance/productivity). It is also important to notice that even if a building is designed for one category, it may still be operated in a higher category during greater part of the year.

Different categories of criteria may, according to ISO EN 7730 (2005) and EN 15251 (2007), be used depending on type of building, type of occupants, type of climate and national differences. These standards specify several different categories of indoor environment which could be selected for the space to be conditioned. These different categories may also be used to give an overall yearly evaluation of the indoor environment by estimation (measurements, simulations) of the percentage of time in each category. The designer may also select other categories using the principles from these standards. **Table 1** shows example of categories from EN15251.

The introduction of categories has initiated discussions on the value and use of them. Especially the following arguments are used against categories:

- People or buildings will be divided in first and second rank;
- Increased energy use for a stricter category;
- In practice you cannot measure if a building is in one category or the other.

The following will deal with the above arguments and explain some of the philosophy behind introducing categories and how they can be used in design and yearly evaluation of the indoor environmental quality.

Table 1. Example criteria for PMV-PPD, operative temperature and ventilation (CO_2) for typical spaces with sedentary activity. (EN15251, 2007)

Class	Thermal Comfort requirements		Operative Temperature range		Ventilation
	PPD	PMV	Winter 1.0clo/1.2met	Summer 0.5clo/1.2 met	CO_2 Above outdoor
	[%]	[/]	[°C]	[°C]	[ppm]
I	< 6	-0.2 < PMV < + 0.2	21.0-23.0	23.5-25.5	350
II	< 10	-0.5 < PMV < + 0.5	20.0-24.0	23.0-26.0	500
III	< 15	-0.7 <PMV < + 0.7	19.0-25.0	22.0-27.0	800
IV	> 15	PMV > + 0.7	< 19.0-25.0<	<22.0-27.0<	800<

Note: In standards like EN ISO 7730, EN 13779 (2004) and EN15251 categories or classes are used; but may be named different (A, B, C or 1, 2, 3 etc.).

Design criteria

For design of buildings and dimensioning of room conditioning systems the thermal comfort criteria (minimum room temperature in winter, maximum room temperature in summer) are used as input for heating load and cooling load calculations. This will guarantee that a minimum-maximum room temperature can be obtained at design outdoor conditions and design internal loads. Even when specifying the design outdoor conditions the use of classes or categories is used. It must be decided at which quartile the design outdoor temperature is estimated i.e. 1%, 2% or 4%. This will have similar influence on the dimensioning and sizing of HVAC systems as different categories for the indoor temperature. Ventilation rates that are used for sizing the equipment shall be specified in design (EN15251).

Based on the selected criteria (comfort category) a corresponding temperature interval is established **(table 1)**. The values for cooling load calculations (dimensioning of cooling systems) are the upper values of the comfort range and values for heating load calculations (dimensioning of the heating system) are the lower comfort values of the range. In determining the acceptable range of operative temperature from ISO 7730, a clo-value that correspond to the local clothing habits and climate shall be used. A more strict class for design will normally result in larger systems and higher costs.

Criteria for energy calculation and operation

Yearly operation inside a more strict class may increase the yearly energy consumption. It is, however important to remember that the energy consumption is regulated by building energy codes (EPBD and energy labelling), so the client/designer will anyhow work within an energy limit. The challenge is then to design and operate the building as large a part of the year in the chosen category or higher. Going to a higher category do not always result in higher energy consumption. As an example in many climatic zones the ventilation rate can be increased by natural means during the seasons were outside temperature is relative close to required indoor temperature.

Even if a building is designed for category II it may still perform a greater part of the year in category I and may perform in category III a part of the year, so the yearly energy consumption may be the same as for operating in category II the whole year.

A very important factor is also people's productivity. If you can increase productivity by selecting a higher category and still be within the energy frame of the building code, you may have a big advantage on the overall budget.

By dynamic computer simulations it is possible for representative spaces in a building to calculate the space temperatures, ventilation rates and/or CO_2 concentrations.

The use of categories to evaluate the indoor environment during operation of buildings based on measurements is more difficult. For the thermal environment it can based on measurements be difficult to be sure if you are in one category or the other. The accuracy by evaluation of the clothing and activity is not good enough to estimate the difference between classes of PMV. But if it is decided that the evaluation is based on fixed clothing and activity (what was specified for design), the influence of the accuracy on clothing and activity estimation disappears and we can express the classes by temperature ranges. The major problem is here the accuracy of the measurement of mean radiant temperature, which often is higher than 0.5 -1.0 K. For many buildings the difference between air and mean radiant temperature is however less than 2 K, and then this accuracy will not be so important.

The following example describes the evaluation of an office building in Denmark. The building is with mechanical ventilation and cooling. In the building the indoor environment was measured over a period of time during winter and during summer in three different zones (B, C, and D) on the first floor.

The histograms of the operative temperature during the cooling (summer) and heating (winter) periods in the occupied hours are given in **figure 1.**

From **figure 1** it can be seen that the highest operative temperature in both winter and summer periods was measured in Zone D, indicating that overheating occurs in this area. The temperature varies less (with a magnitude of 2.5 K) in Zone B compared to the other zones. Moreover, the temperature in this zone is generally lower in both summer and winter periods than in Zones C and D.

The operative temperature distribution for the 1st floor in accordance with the standard EN15251 is given in **table 2.**

From the temperature distribution in classes in **table 2** it can be seen that all zones show better performance in the summer period, where most of the time the operative temperature is in a range of 23.5–25.5°C corresponding to the highest category I. In summer period none of the zones and consequently the entire 1st floor has never a category lower than the permissible III, indicating that the cooling system is working properly and is able to cover the internal and external heat loads.

During the winter period the temperatures most of the time are higher than 23.0°C. Zone D can be considered as the most critical zone, where

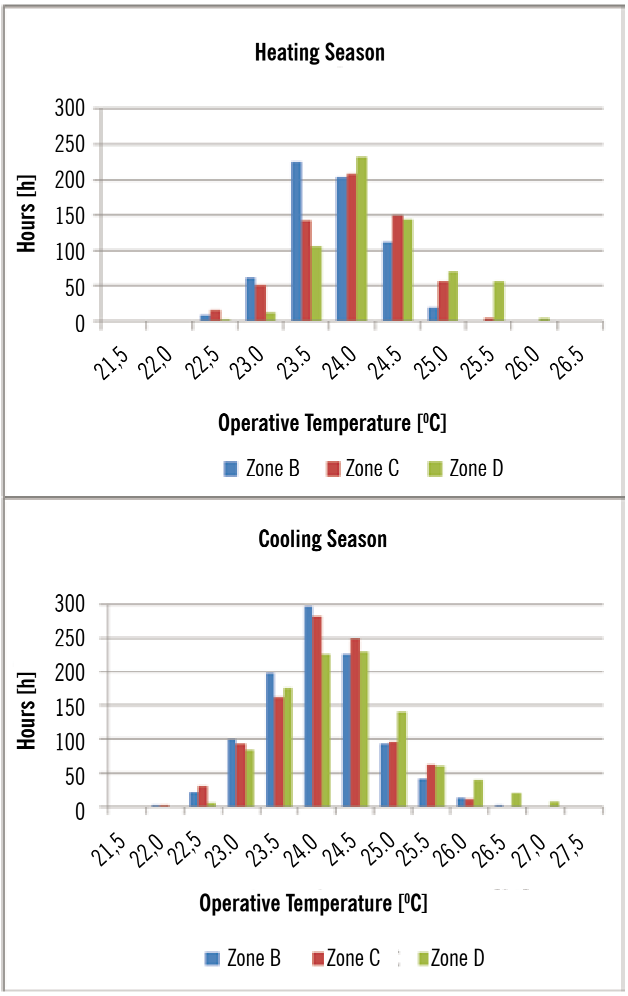

Figure 1. Histograms of the operative temperature during the cooling and heating season from 9:00 to 17:00

Table 2. Quality of thermal environment in % of time in four categories

	Percentage [-] in Winter period			
	I (21.0 - 23.0°C)	II (20.0 - 24.0°C)	III (19.0 - 25.0°C)	IV (Other)
Zone B	11,3	79,2	100,0	0,0
Zone C	11,0	66,8	99,4	0,6
Zone D	2,5	56,3	90,3	9,7
1st Floor	8,3	67,4	96,6	3,4
	Percentage [-] in Summer period			
	I (23.5 - 25.5°C)	II (23.0 - 26.0°C)	III (22.0 - 27.0°C	IV (Other)
Zone B	86,2	97,5	100,0	0,0
Zone C	86,2	96,8	100,0	0,0
Zone D	84,2	96,7	100,0	0,0
1st Floor	85,5	97,0	100,0	-

almost 10% of time the temperature is higher than 25.0°C. The overheating occurs probably because of the high internal heat gains, e.g. from people and office equipment. On the contrary, the temperature in Zone B always complies with category III. When considering the entire performance of the 1st floor, the temperature is 3.4% of time outside the range for category III.

Discussion and conclusions

The present paper has presented and discussed the use of categories (classes) when specifying criteria for the indoor environment. In international standards it can often be difficult to set criteria, which will be acceptable in all countries. Therefore the use of classes/categories is a common concept for taking into account these differences. One country may then, in their national standards or building codes, decide to select one category for criteria. Other countries may decide to give the flexibility to the builders and consultants. For the engineering society it is common to have to make choices in the design process so to choose among different levels of design criteria only introduces more flexibility. It is however important that the acceptable categories will not result in any health problems. There may be differences in comfort and productivity levels of the occupants.

The main idea behind the categories is to use them in design of buildings and HVAC systems and to use them when evaluating the yearly performance of buildings regarding the indoor environment. The intention is not to force the operation of a building within one class the whole year.

Different categories may influence the sizes and dimensioning of HVAC systems; but not necessarily the energy consumption, which is regulated through building codes and energy certification. Even if a building is designed for a lower category it will still be possible to operate the building the majority of the year in a higher category.

For building with HVAC systems the categories are based on different levels of the PMV-PPD index. If all the factors included in the PMV-PPD index must be measured or evaluated the accuracy is not good enough to be able to distinguish between some of the classes. In practice, however the clothing and activity level is fixed (design values for computer simulations and evaluation of existing buildings) and in most cases the criteria is then formulated as a temperature range. This is the equivalent to the categories for natural ventilated buildings, where the categories are also based on temperature ranges.

References

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