Transient Aspects of thermal comfort according to the EN 16798-1

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Background

ISO 7730 [1] is the most important standard for assessing thermal comfort in buildings. At European level, ISO 7730 is supplemented by EN 16798-1 [2], which is currently being revised and after the revision, the standard will be given a new name (number). The revision of this standard introduces a new structure that is intended to give greater weight to the individual trades addressed. The new structure is divided into five parts as follows (see **Figure 1**):

- part 1-1 – Overarching Structure
- part 1-2 – Thermal Comfort
- part 1-3 – Indoor Air Quality
- part 1-4 – Lighting
- part 1-5 – Acoustics

Input conditions for the design and energy demand calculation of technical systems in the building are considered in all parts. Only Part 1-2 (thermal comfort) will be considered below. Aspects of the design of technical systems regarding room temperature and relevant comfort criteria are documented here. All parameters

Symbols

ϑ	temperature in °C
ϑ_{op}	operative room temperature in °C
$\Delta\vartheta$	temperature difference in K
PMV	predicted mean vote in -
τ	time in s

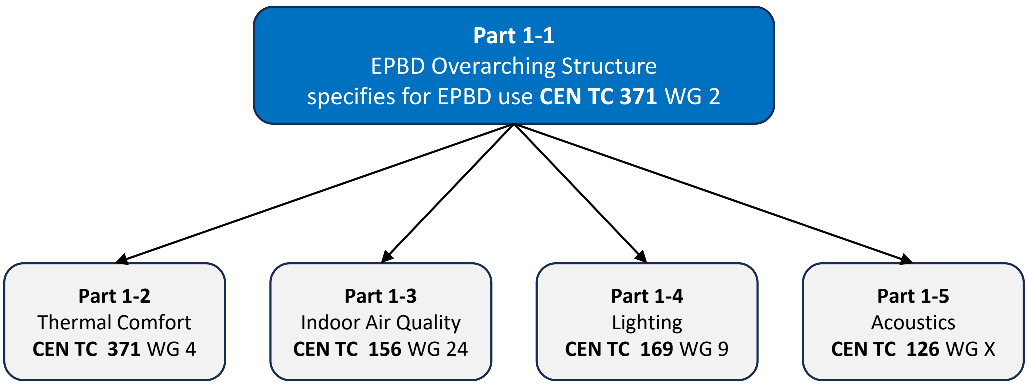

Figure 1. Structure of the new EN 16798-1.

represent stationary parameters. Transient aspects are not considered. However, if one considers the scope of validity of the above-mentioned standard, the focus is not only on the design but also on the calculation of energy requirements. However, energy considerations in the building sector are usually transient, which means that focusing exclusively on stationary aspects in the standard is not expedient. Instead, transient aspects should also be considered with a view to operational management. ISO 7730 provides a point of reference for this, in which dynamic aspects in the form of

- temperature cycle
- temperature drifts and gradient
- temperature transitions

are to be described (see **Figure 2**).

However, the ISO 7730 only specifies boundary conditions under which the stationary criteria can be used to assess thermal comfort. In particular, the aspect of reheating after a night set back, which is important in practice, is not addressed.

Against this background, analyses were carried out at TU Dresden to specifically analyse the issue of thermal comfort under transient conditions. Based on ISO 7730, two scenarios were analysed, which are described in detail below.

Investigation Setup

With the "Combined energy Lab", the TU Dresden has a test bench facility with which extensive energy analyses can be carried out in the field of building energy technology. The indoor climate room can be used to carry out stationary and transient analyses of thermal comfort. The indoor climate room has a floor area of 20 m² and a height of h = 2.5 m. The surface temperature of all enclosure surfaces can be varied separately. In addition, different forms of ventilation can be realized in the room. For detailed descriptions, please refer to [3], [4] and [5].

Male and female test subjects were used for the analyses. A total of 84 people were involved in the experiment. A distribution of the test subjects according to age is shown in **Figure 3**.

As can be seen from **Figure 3**, the test subjects do not fully represent an ideal age distribution. Despite intensive efforts, there is a higher proportion of people between the ages of 20 and 40. It is striking that the women are younger than the men.

Regarding the experiment, an initialization phase was carried out first. The test subjects were able to choose their own operative room temperature. If no stationary target temperature had been selected by the subjects after one hour, the scientific staff set the operative room temperature to ϑ_{op} = 22 °C. Two experiments were carried out in the actual test phase. In the first experiment, the temperature was increased by $\Delta\vartheta$ = +2 K from the self-selected operative room temperature within one hour (heating case).

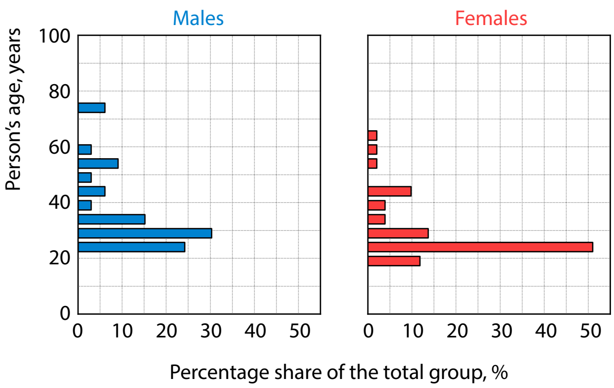

Figure 3. Age distribution of the test subjects.

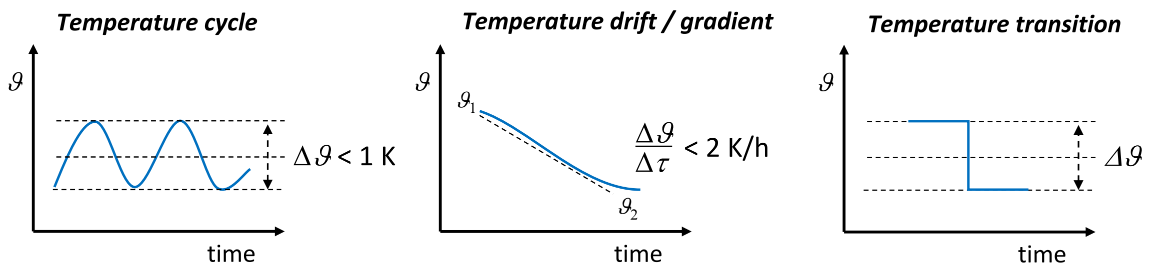

Figure 2. Structure of the new EN 16798-1.

In the second experiment, the cooling case was addressed, and the room temperature was reduced by $\Delta\vartheta = -2$ K within one hour. **Figure 4** shows the procedure regarding the temperature curve in the experiment.

At the end of the experiment, the temperature was returned to the operating room temperature selected at the beginning.

Results of the Investigation

The first result of the investigation relates to the operative room temperature selected by the test subjects themselves. **Figure 5** shows the temperature distribution.

Over 60% of the test subjects chose a temperature between $21.5 < \vartheta_{op} \leq 22$ °C in the experiment. Temperatures between $22 < \vartheta_{op} \leq 23$ °C were chosen by approx. 20% of people. Small proportions were in the ranges $\vartheta_{op} \leq 21.5$ °C and $\vartheta_{op} > 23$ °C. This result impressively confirms the operative room temperature of $\vartheta_{op} = 22$°C documented in ISO 7730 / EN 16798-1 as the decisive room temperature in building energy technology.

For the dynamic analyses, online surveys on the thermal room situation and the change request were conducted at 10-minute intervals. **Figure 6** shows the questions and the possible answers regarding thermal comfort. ▶

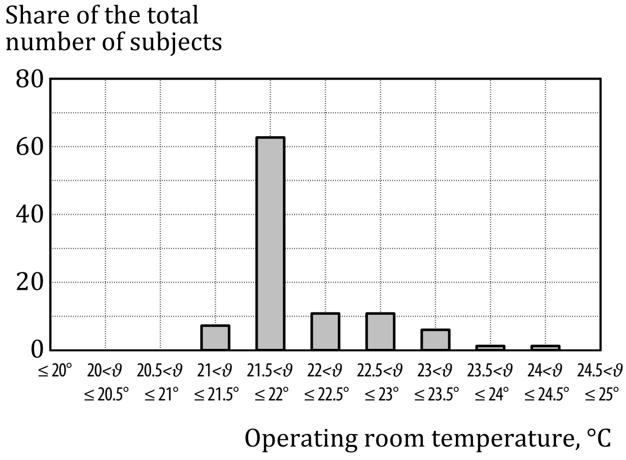

Figure 5. Share of the total number of subjects depends on ϑ_{op}.

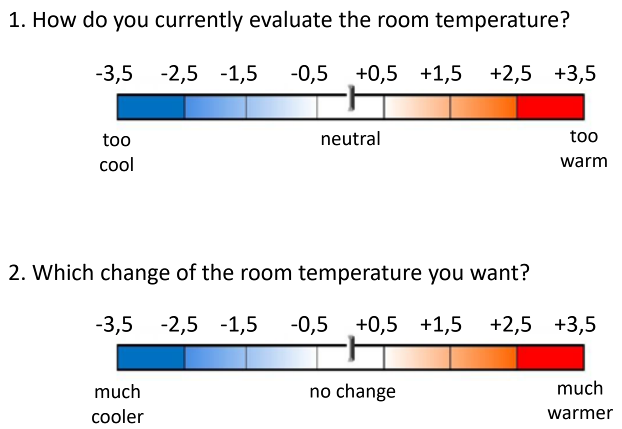

Figure 6. Questions regarding thermal comfort.

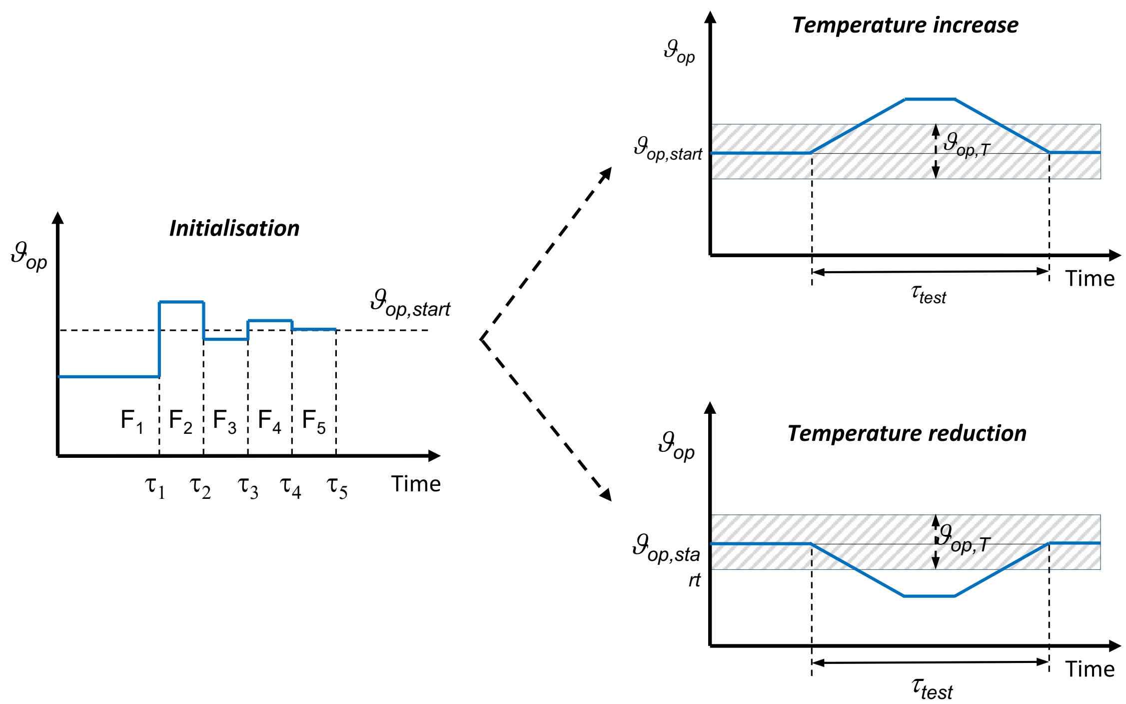

Figure 4. Initialisation phase and temperature curve during the experiments (basic representation).

▶ The results of the dynamic analyses are documented in **Figure 7 and 8**. **Figure 7** shows the heating case with an overheating of $\Delta\vartheta = +2$ K and **Figure 8** the cooling case with an underheating of $\Delta\vartheta = -2$ K.

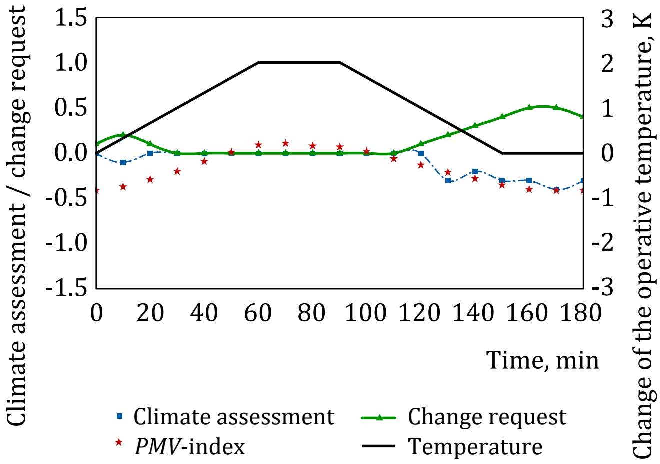

Figure 7. Heating case - transient investigations.

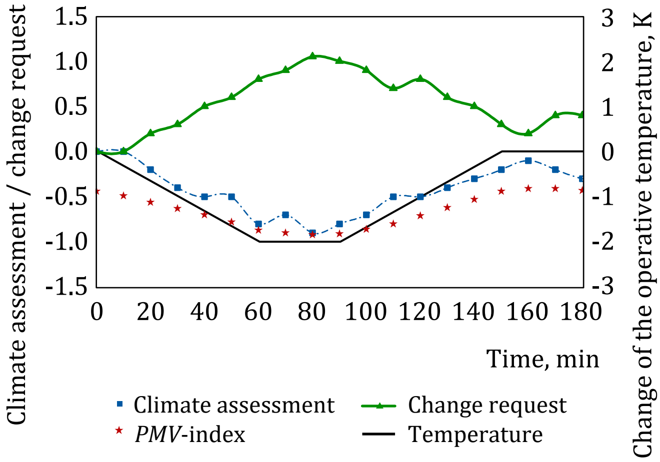

Figure 8. Cooling case - transient investigations.

In addition to the experiments with variable room temperature, a "control experiment" was carried out in which the operative room temperature was not changed (**Figure 9**). The test subjects did not know how the room temperature changed during the experiments.

The results of the **heating case** (**Figure 7**) clearly show that room temperatures above the selected setpoint are accepted by the test persons. The desire for change tends towards "0" here. However, if you look at the end of the experiment, you can see that the test subjects have become accustomed to the higher room temperatures and find a return to the original setpoint temperature they selected too "cold". The desire for change here tends towards higher room temperatures again.

If you look at the results for the **cooling case** (**Figure 8**), you can see that the test subjects want higher room temperatures as soon as the room temperatures drop. This can be seen directly after the operative room temperature drops by $\Delta\vartheta = -0{,}2$ K. In the dynamic case, it can also be seen that in the heating phase at the end of the experiment, the test subjects' desire for change decreases very quickly. This can be interpreted with the positive gradient in the direction of their own selected operative room temperature.

The **control case** (**Figure 9**) shows that the *PMV* index lies within a range of $-0.5 \leq PMV \leq 0$ during the entire experiment "without changing the room temperature". The desire for change is also subject to only minor fluctuations and is constant at 0.5. This result shows that the gross energy turnover of the test subjects did not change during the experiment.

Figure 10 shows a comparison of the different dynamic analyses for the *PMV* index. The immediately negative evaluation with falling room temperatures can be clearly recognized here.

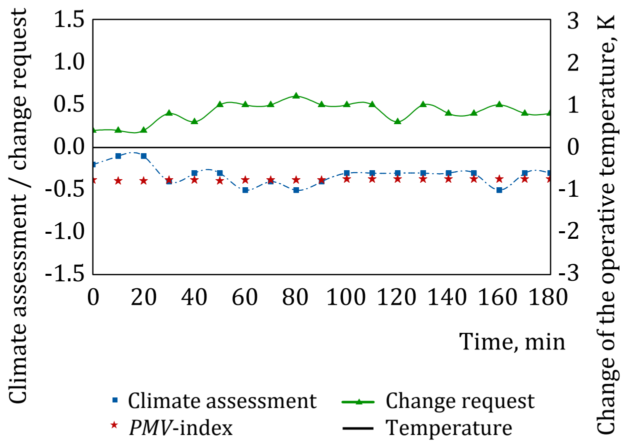

Figure 9. Control case – transient investigations.

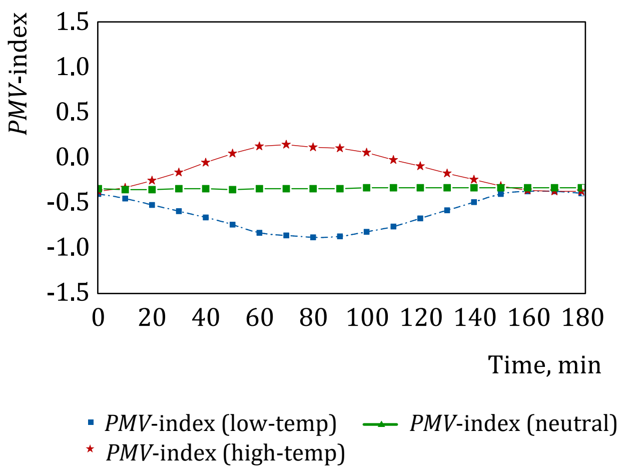

Figure 10. Comparison between the different investigations.

Table 1. *Proposal for adapting the comfort categories in EN 16798-1 / ISO 7730 regarding the operative temperature.*

Type	Activity in W/m²	Category	Operative temperature ϑ_{op} in °C	Temperature difference ϑ_{op} in K
individual office / office landscape / conference room / auditorium / cafeteria / restaurant / classroom	70	A	22	+ 1 K / –0,2K
		B	22	+2 K / –0,2 K
		C	22	+3 K / –0,2 K

Conclusions for the revision of the EN 16798-1 (thermal comfort part)

The results of the dynamic tests show innovations that should be considered in the revision of EN 16798-1. The results clearly show that there are no equivalent conditions for overheating and undercooling regarding the tolerance range. The current practice in EN 16798 is a symmetrical tolerance band. This cannot be confirmed with the present results. Particularly under transient conditions, a change request is already registered by the users from a temperature undershoot of $\Delta\vartheta = -0,2$ K. For the heating case, the comfort classes of EN 16798-1 should be adapted according to **Table 1**.

Literature

[1] ISO 7730: Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the *PMV* and PPD indices and local thermal comfort criteria (ISO/DIS 7730:2023); German and English version prEN ISO 7730:2023.

[2] EN 16798-1: Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics - Module M1-6.

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