NATVENT BUILDINGS VERSUS HVAC BUILDINGS - A NEW DUTCH THERMAL COMFORT GUIDELINE

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ABSTRACT

A new thermal comfort guideline for moderate environments has been developed: the ATG guideline. The underlying method distinguishes between ‘type Alpha’ versus ‘type Beta’ buildings to provide for different adaptation effects. Type Alpha indicates buildings with a major occupant influence on the indoor environment, as characteristic for buildings with natural ventilation. Type Beta instead stands for a centrally controlled indoor environment, such as in most buildings with sealed facades and full HVAC.

The ATG method has some major improvements over the former, PMV based, method:

1. Higher temperatures are accepted in type Alpha buildings during warm periods, putting less demand on mechanical cooling. As a result, improved energy efficiency is expected.
2. As thermal demands in type Alpha buildings are less stringent, it is easier to make naturally ventilated buildings meet the criteria than before. This improves chances for retrofitting older buildings and for the application of advanced natural or hybrid ventilation in new buildings. Demands for type Beta buildings remain practically as before.
3. The new criterion is easy to communicate. Thermal comfort as building performance is now expressed as *Class A*, *B*, or *C*, in accordance to international standards like CR1752.
4. In contrast to the old guideline, the predicted performance can now be tested with field measurements. This means that the performance that was agreed upon in the pre design phase can be assessed during occupation. This makes performance contracting possible.

The ATG guideline has been published in March 2004 and it is expected to become the official guideline for government commissions in the Netherlands.

KEYWORDS

Adaptation, thermal comfort, ATG, guideline, Alpha, Beta

INTRODUCTION

Over the last 10 years natvent and hybvent have regained popularity in Dutch building practice. The existing Dutch thermal comfort guideline, based on the PMV model, has proven less suitable for such ‘low tech’ environments: the occupants of such buildings seem to expect a less stringent temperature than the existing guideline prescribed. Meanwhile there is a rising attention for performance based design, requiring performance criteria that can be tested after construction. These developments were the basis for developing a new thermal comfort guideline. The new guideline was to be used for design and field assessment of buildings with extensive climate control systems as well as buildings with simple systems, such as natural ventilation. Furthermore the new guideline was to improve communication about thermal comfort to the building principal, usually a layman on this subject.

METHODS

A thorough literature review of field studies and laboratory studies (ISSO, 2002) was carried out to investigate developments after the release of the former thermal comfort guideline. Also national and international comfort guidelines and standards were evaluated, including unpublished draft versions of international standards (e.g. draft ASHRAE standard 55 and draft EN-ISO 55). Further analysis of the ASHRAE RP-884 database was carried out. A workshop (de Wit, 1999) was held to gather comments of professionals who use the existing guidelines in practice. Field research (Raue, 2001) was done to test some findings in the Dutch situation. At several phases the researchers consulted Richard de Dear, whose findings (de Dear and Brager, 2001) formed a major contribution to the new guideline.

RESULTS

The new Dutch thermal comfort method is called the ATG method, ATG being an acronym for *Adaptieve Temperatuur Grenswaarden*. It is meant for moderate indoor environments, with the main emphasis on office buildings (metabolism 1,2 - 1,4 met; clothing in the 0,5 - 1,0 clo range). In less moderate circumstances, a PMV based method is likely to be more accurate. For an extensive explanation of the rationale behind the proposal we refer to Van der Linden et al, 2004. The quantitative data that the comfort limits are based upon, are derived from de Dear & Brager (2001). The thermal comfort model that was used is based on the "adaptation hypothesis" of thermal perception developed by Auliciems et al (1981).

The ATG guideline is based upon a *neutral temperature* that changes every day, as the occupants' expectation and clothing change with the weather. The ATG neutral temperature is calculated from the daily maximum and minimum outside temperatures over 4 days. The difference between the actual operative temperature and ATG neutral temperature defines the buildings' performance. Buildings of the Alpha type allow for a higher neutral temperature in the summer. The calculation of the ATG neutral temperature, performance classification and the Alpha type are explained in further detail below:

Neutral Temperature

The neutral temperature is most straightforward in Type Beta buildings. It is defined as:

$$T_{neutral,\ Beta} = 21{,}45\ ^{\circ}C + 0{,}11 \bullet T_{e,ref}$$

$T_{neutral}$ represents an *operative temperature*, which is roughly the average of the air temperature and radiant temperature in a room.

Reference Temperature: $T_{e,ref}$

Analysis of field studies (e.g. Morgan & de Dear, 2003; Oseland & Humphreys, 1994) showed that the amount of clothing people wear inside correlates strongly with the Running Mean Outside Temperature, which is a 'synthetic' outside temperature that integrates over the day of exposure and a couple of days before. It was assumed that in general the time-dimension of thermal adaptation is of the same order as the time-dimension of clothing adaptation. For practical reasons a numerical simplification of the RMOT is introduced, called $T_{e,ref}$. In formula:

$$T_{e,ref} = \frac{1 \cdot T_{out,\ today} + 0{,}8 \cdot T_{out,\ yesterday} + 0{,}4 \cdot T_{out,\ 2\ days\ ago} + 0{,}2 \cdot T_{out,\ 3\ days\ ago}}{2{,}4}$$

When estimating the 'outdoor temperature' on a certain day (today, yesterday etc.) one should calculate the average from the maximum and minimum outdoor temperature of that day. These data can be collected from local weather stations or mass media.

Classification

In accordance to international standards such as CR1752, performance is expressed in four classes in which Class A stands for a particularly good indoor environment, Class B for good common practice and Class C for lowest desirable performance. Class D is actually a rest category for environments where even class C criteria are not met. The ATG performance classes are defined as *bandwidths* around the neutral temperature:

Class $A_{,Beta}$ = 90% acceptability = $T_{neutral,Beta} \pm 1{,}25$ K.
Class $B_{,Beta}$ = 80% acceptability = $T_{neutral,Beta} \pm 2{,}0$ K.
Class $C_{,Beta}$ = 65% acceptability = $T_{neutral,Beta} \pm 2{,}5$ K.

If these bandwidths are exceeded at any moment during occupation hours of the building (so not at night, in weekends or holidays!), the building falls into the next class. For instance: if the Class A limits are exceeded during only a couple of hours per year, the buildings' performance is class B or lower.

Expressed graphically, the classification bandwidths of Type Beta relate to $T_{e,ref}$ as follows:

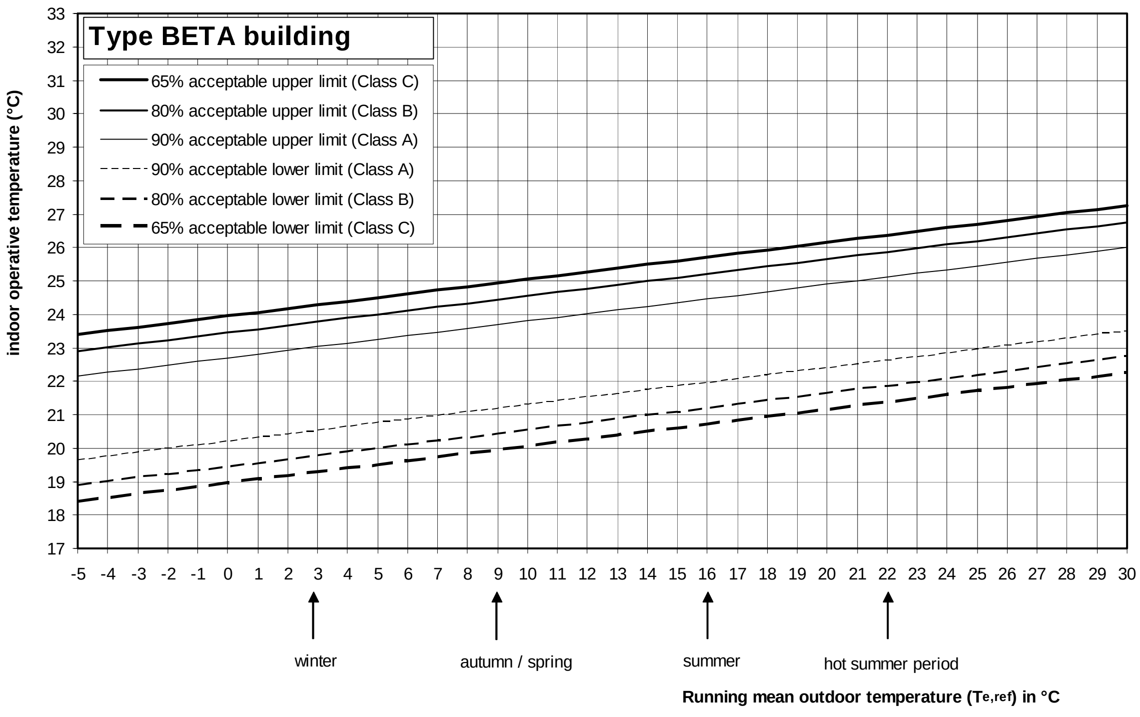

Figure 1: upper comfort limits for the operative indoor temperature (based on the results of de Dear & Brager, 2001) for type Beta spaces in relation to outdoor temperature $T_{e,ref}$.

Type Alpha

Many studies, for instance Oseland & Humphreys (1994), de Dear & Brager (2001) and Humphreys et al (2001), suggest that in buildings with operable windows less stringent criteria should be used than in buildings with centrally controlled climate systems and closed facades due to the 'adaptation factor'. In the ATG method, these distinctive building/climate types are referred to as type Alpha and type Beta.

In the paragraphs above, the method for the type Beta was described. The method for type Alpha is similar, except for that in warm periods ($T_{e,ref}$ > 10°C) $T_{neutral}$ regression is steeper and the upper bandwidths are bigger:

$$T_{neutral,\ Alpha} = 17{,}8\ °C + 0{,}31 \bullet T_{e,ref}$$

The upper temperature limits for type Alpha buildings, when $T_{e,ref}$ > 10°C, are:

Class A_{Alpha} = 90% acceptability = $T_{neutral,\ Alpha}$ + 2,5 K.
Class B_{Alpha} = 80% acceptability = $T_{neutral,\ Alpha}$ + 3,5 K.
Class C_{Alpha} = 65% acceptability = $T_{neutral,\ Alpha}$ + 4,2 K.

On days when $T_{e,ref}$ is 10°C or lower, the neutral temperature and bandwidths are similar to those of type Beta.

Graphically, the classification bandwidths of type Alpha relate to $T_{e,ref}$ as follows:

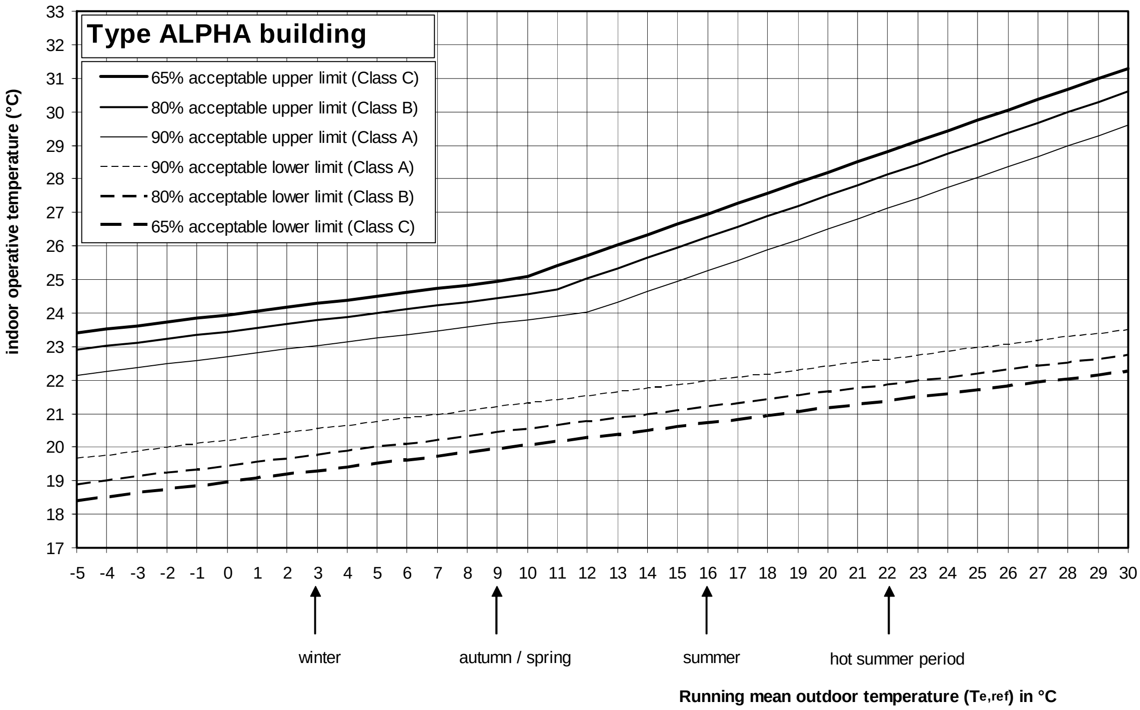

Figure 2: Upper comfort limits for the operative indoor temperature (based on the results of de Dear & Brager, 2001) for type Alpha spaces in relation to outdoor temperature $T_{e,ref}$.

It is possible to have both type Alpha and Beta spaces in one building, dependent on the characteristics of each space. The distinction between type Alpha and Beta is basically to be made upon the degree in which the occupant can actually control his thermal environment, combined with expectation (to put it simple: an occupant expects and so accepts higher temperatures in a building with no air conditioning). It is very complicated to fully model all factors that influence perceived control and expectation. Figure 3 shows a simplified model:

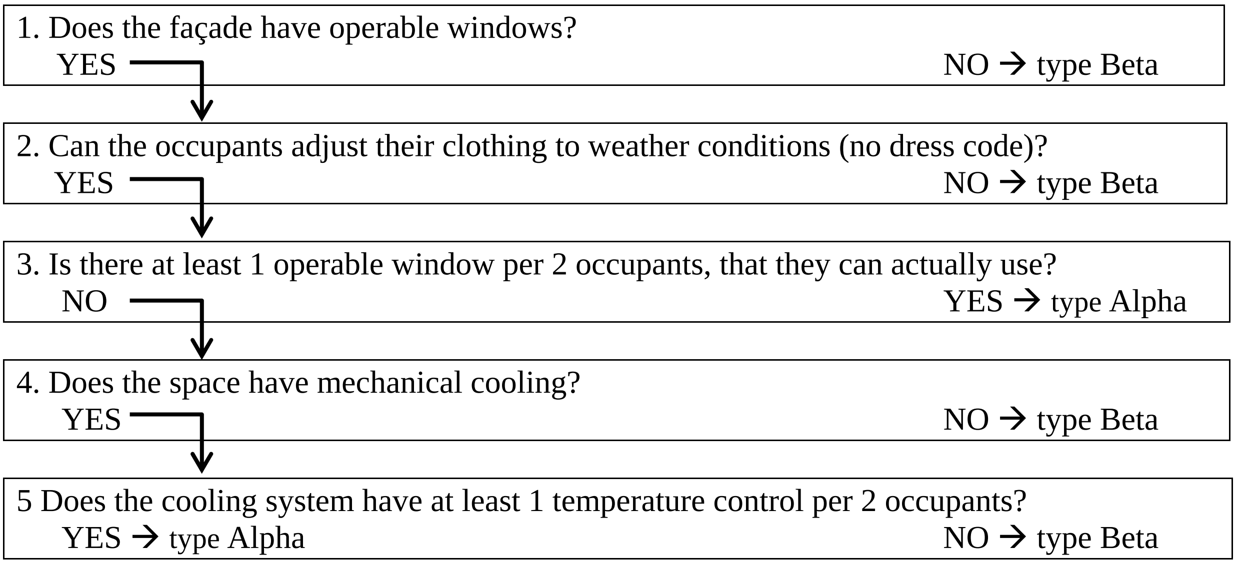

Figure 3: Flowchart for the determination of the building/context type. Type Alpha refers to a building that allows for a high degree of occupant control, Beta to a rather centrally controlled context.

Example

Figure 4 is an example of measurements evaluation in a type Alpha room in an office building. The top- and bottom temperature limits differ per day, as they depend on the daily average outside temperature. In this example the temperature as measured stays within the 80% bandwidth. Therefore, this example shows 'class B thermal performance'.

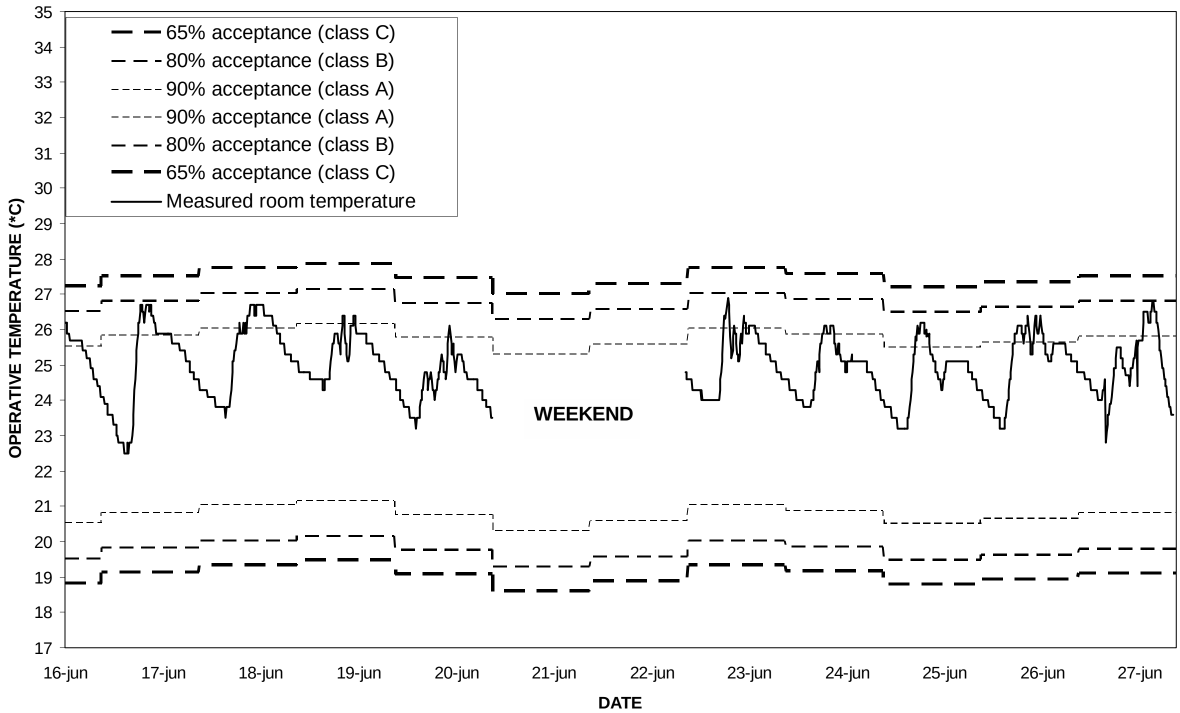

Figure 4: example of measurements evaluation in one room in a type Alpha office building.

CONCLUSIONS AND IMPLICATIONS

With the ATG method thermal comfort performance of buildings can be assessed and communicated.

- It can be used in buildings with sealed facades, full HVAC systems and little occupant influence on the environment, referred to as type Beta. For type Beta, results are quite similar to when the PMV model is applied.
- In contrast to many other methods, it is also validated for environments with simple climate systems and a relatively high grade of occupant control (type Alpha), for instance:
  - Evaluation of older buildings
  - Retrofit situations
  - Buildings with natural ventilation.
- The method can be used for design evaluation: assessment of temperature simulation results, based on building geometry and a standard climate year.
- The method can be used for the indicative assessment of momentary temperatures in a building, comparing the temperature as measured to the classification bands on that day.
- The method can also be used for long term assessment of thermal performance of a building, in cold as well as in warm periods.

The method will be evaluated in practice during the next 2 years in order to further improve its implications.

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