PROPOSED NORDIC STANDARD FOR VENTILATION AND THERMAL COMFORT

P. O. Fanger

Lab. of Heating & Air Conditioning
Technical University of Denmark, Bldg. 402
DK 2800 Lyngby, Denmark

ABSTRACT

A proposal is presented for an Indoor Climate Standard, to be included in the building codes of the Nordic countries[1]. The standard comprises two parts: (1) air quality and ventilation, (2) thermal environment. The paper presents and discusses the main features of the two parts of the standard. Mechanical ventilation is required in all buildings including dwellings at a minimum outdoor air change of 0.5 h^{-1}. Limits for operative temperature and for thermal non-uniformity are given for winter and summer conditions. The proposal is a basis for designing energy efficient buildings while maintaining an indoor climate which provides acceptable comfort and does not impair health.

KEYWORDS

Indoor climate, ventilation, air quality, health, comfort, discomfort, thermal comfort, thermal environment, energy conservation.

INTRODUCTION

This paper presents a proposal for an Indoor Climate Standard for the Nordic countries[1]. The proposal is drawn up by a subcommittee of the Nordic Committee for Building Codes (NKB). The idea is to include identical regulations on indoor climate in the National Building Codes of the five countries. Whether the proposal will be adopted as it is, is not known at the present time.

The background for the work is the influence of different common energy conservation strategies on indoor climate. A cheap way to save energy is to tighten buildings, decrease ventilation and lower the temperature. This has caused many complaints from occupants, and scientists have been worried about the possible health effect of the indoor climate under these new conditions.

Remarkably little information on indoor climate is included in the present building codes in the Nordic countries or in other countries. This tends to downgrade

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[1] Denmark, Finland, Iceland, Norway, and Sweden.

and ignore the indoor climate compared to other areas where specific requirements are listed in the building code: for instance, requirements on fire safety, structure, sanitary systems, insulation, and energy use.

It was therefore decided to elaborate a standard specifying for the first time the minimum requirements for an indoor climate which is acceptable to the occupants and will not impair health. The standard applies to all new buildings except recreational buildings, industrial buildings and hospitals. The standard comprises two parts: (1) air quality and ventilation, (2) thermal environment. This paper presents and discusses the main features of each of the two parts of the standard.

AIR QUALITY AND VENTILATION

The general purpose is to establish a quality of indoor air which is acceptable to human occupants and does not impair health. The most logical method is to specify maximum permissible concentrations of contaminants in the indoor air. Unfortunately, information on permissible concentrations and on the emission of contaminants from building materials and from many other sources is still very limited. It was therefore felt that such a performance method was not yet useful for design. Instead, it was decided to use the indirect, prescriptive method, namely to specify the required ventilation, i.e., the rate of outdoor air to be supplied to each space. To be used without treatment, the quality of the outdoor air should meet the minimum requirements listed in Table 1. This will seldom be a problem in the Nordic countries, but in special cases where the requirements listed in Table 1 cannot be met, the air should be cleaned or alternative positions for the intake of outdoor air may be selected.

TABLE 1 Allowable Concentrations of Contaminants in Outdoor Air for Ventilation

Contaminant	Averaging time	Time weighted average
Particulate matter	1 yr. 24 h	60 μg/m^3 150 μg/m^3
Sulphur Dioxide	1 yr. 24 h	60 μg/m^3 260 μg/m^3
Photochemical Oxidants	1 h	120 μg/m^3
Hydrocarbons (not methane)	3 h	160 μg/m^3
Nitrogen Dioxide	1 yr. 1 h	100 μg/m^3 200 μg/m^3
Lead	3 mo.	1.5 μg/m^3
Odors	no discomfort	

Dwellings

Most people spend the major part of their life in their dwelling. It is therefore of special importance to maintain an air quality that does not impair health and comfort. For many years this was no problem since buildings were generally untight and had a rather high natural ventilation with an air change typically higher than 1 h^{-1}. The progressive increase in the cost of energy has motivated the development of much tighter constructions. The natural air change in new houses in the Nordic countries is now typically around 0.1-0.2 h^{-1}. With such low ventilation, excessively high concentrations of several contaminants can easily occur.

One contaminant in indoor air is radon (and daughters) which may cause lung cancer. Radon emanates from building materials or from the ground. Another group of contaminants comprise compounds outgassing from building materials, and furniture, like formaldehyde, which may create eye and airway irritation. Humidity in dwellings may be too high, causing the growth of molds and mites. House dust mites cause the frequently occurring house dust allergy.

To maintain contaminants at an acceptable level the proposed standard requires mechanical ventilation in all dwellings at an outdoor air change of 0.5 h^{-1}. This air change should be maintained both in the dwelling as a whole and in each individual sitting- or bedroom. To obtain a reasonably low CO_2-percentage in each bedroom a minimum of 4 l/s per person is also required.

In the kitchen and in each bathroom an exhaust air flow of 10 l/s is prescribed. It should be possible to increase this exhaust air flow to 30 l/s when required (during cooking and bathroom occupancy).

The mechanical ventilation may be established by an exhaust system or by a combined supply and exhaust system. In the untight naturally ventilated house the ventilation, and therefore the indoor air quality, depends on wind and outdoor temperature. Energy for ventilation is spent whether the house is occupied or not. In the tight, mechanically ventilated house the air quality is independent of weather and the house is only ventilated when occupied. The energy efficiency of the mechanically ventilated house may be further improved by heat recovery.

Commercial and Institutional Buildings

As in dwellings, outgassing from building materials and furniture occur. The same minimum outdoor air change of 0.5 h^{-1} is therefore required. But due to varying ceiling heights this requirement is here expressed as 0.35 l/s per m^2 floor area. In commercial buildings with moderate occupancy this figure determines the required ventilation. In spaces with higher occupancy the ventilation must be increased to handle the odors emitted from the occupants. In Fig. 1 the required outdoor air per occupant is given. Curve a is based on Yaglou's classical studies (1936), these still providing the best available information on human odors. At the required ventilation, visitors to the space are predicted to judge the odor intensity as acceptable just after they enter the space. The required ventilation decreases with increasing space volume per occupant but, in order to maintain a reasonably low CO_2-content, it should not be lower than 4 l/s per person (see Fig. 1).

Smoking has a marked influence on the ventilation requirement. For reasons of hygiene and energy conservation it is expected that buildings in the future will be divided into smoking and non-smoking zones. For spaces where smoking is allowed it must be possible to increase the ventilation by 5 l/s per person during smoking, as shown in Fig. 1 (curve b). At a normal smoking intensity of 1.3 cigaret/h·person this ventilation will cause the total suspended particulate in the space air to be

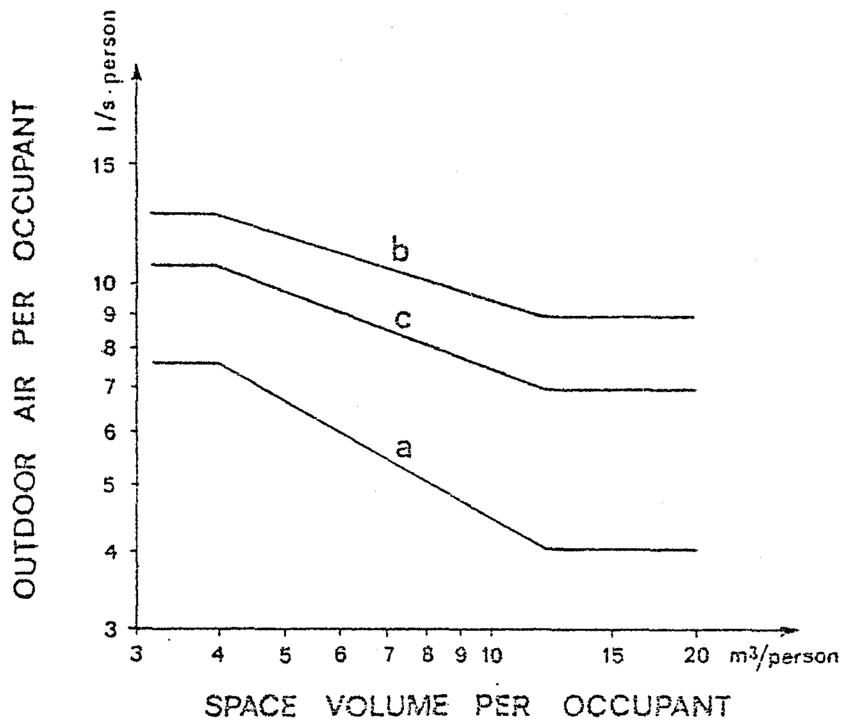

Fig. 1. Outdoor air ventilation required as a function of space volume per person.
Curve (a): no smoking, Curve (b): smoking allowed, Curve (c): smoking allowed, air recirculated and filtered.

less than 5 mg/m^3. By filtering recirculated air the required outdoor air may be decreased as shown on Fig. 1 (curve c).

THERMAL ENVIRONMENT

The general purpose is to specify thermal environments which will provide acceptable comfort for the occupants and do not impair health.

Thermal comfort is defined as that condition of mind which expresses satisfaction with the thermal environment. Dissatisfaction may be caused either by warm or cool discomfort for the body in general or by local discomfort due to undesired heating or cooling of one particular part of the body (e.g. cold feet, warm head, draft at the neck, etc.).

Due to individual differences it is impossible to specify a thermal environment that will satisfy everybody. The aim of this standard is to specify conditions that will be experienced as acceptable to at least 80% of the occupants.

Heating Period (Winter Conditions)

In spaces for light, mainly sedentary, activity the operative temperature in the occupied zone should be maintained within the interval 20-24°C. This interval corresponds to usual indoor winter clothing (1 clo) and light, mainly sedentary, activity (1.2 met), typically occurring in offices and dwellings. The temperature interval is based on a PPD* of 10%. In spaces for higher activities or other clothing the optimal operative temperature can be found from Fig. 2.

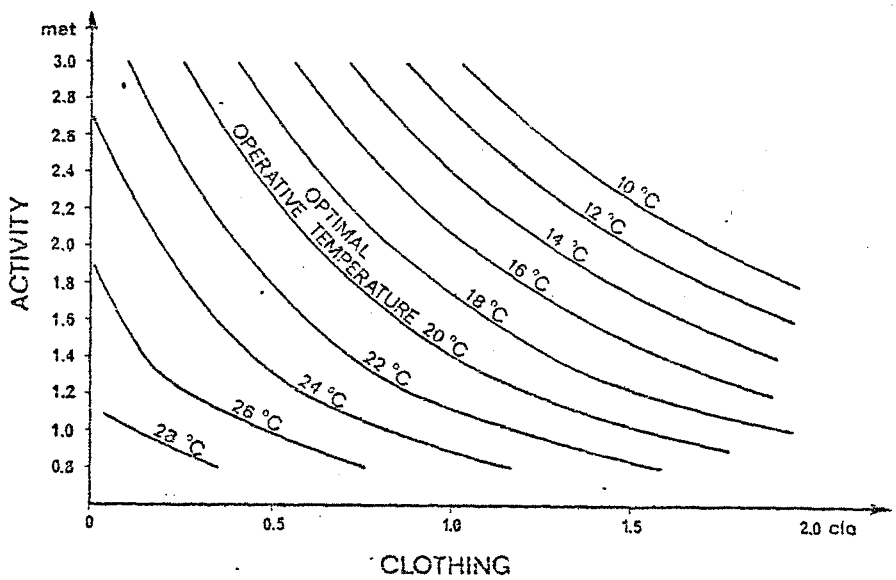

Fig. 2. The optimal operative temperature (preferred by most people) as a function of clothing and activity. Light, mainly sedentary, activity corresponds to 1.2 met. Typical indoor clothing during winter is 1 clo, during summer 0.5 clo.

The operative temperature in the occupied zone should be maintained within an interval of ±2°C around the optimal temperature. The activity and the clothing may be estimated from tables included in the standard.

In spaces for light, mainly sedentary, activity the following further criteria apply in the occupied zone:

- The vertical air temperature difference between 1.1 m and 0.1 m above the floor (head and ankle level) should be less than 3K.

- The mean surface temperature of any 1 m x 1 m area should be

  $\geq$ 19°C

  $\leq$ 26°C above warm spaces, e.g. a boiler room

  $\leq$ 29°C with floor heating systems.

*Predicted Percentage of Dissatisfied (Fanger, 1973).

• The mean air velocity should be less than 0.15 m/s.

• The radiant temperature asymmetry* from windows or other cold surfaces shold be ≤ 10K (in relation to a small vertical plane 0.6 m above the floor and parallel to the window).

• The radiant temperature asymmetry* from a heated ceiling should be ≤ 5K (in relation to a small horizontal plane 0.6 m above the floor).

The above-mentioned factors may all create local discomfort on the human body and each of the limits has been selected at a level where less than 5% of the occupants are predicted to feel local discomfort.

Periods Without Heating (Summer Conditions)

In spaces for light, mainly sedentary, activity (1.2 met) and usual indoor summer clothing (0.5 clo) the operative temperature should be lower than 26°C when the daily mean temperature outdoors is not exceeded more than an average of 30 days per year. This corresponds approximately to 100 degree hours per year where the operative temperature may be higher than 26°C.

A calculation is required to demonstrate that this can be fulfilled. By proper design of the building, refrigeration will normally not be required in the Nordic countries. But a simplified calculation is necessary, even for houses, to demonstrate that high temperatures seldom occur, and if the temperature requirement is not met, to modify the building design including windows, shading, orientation, etc.

OTHER NEW STANDARDS IN PROGRESS

Work on indoor climate standards takes place at the same time in other organisations. On air quality and ventilation ASHRAE is in 1980 proposing a new standard 62-73R. On thermal comfort ASHRAE (Standard 55-74R) and ISO (TC159/SC/WG1) are in 1980 proposing standards which are very similar to the Nordic proposal.

CONCLUSION

The present proposal provides perhaps the hitherto most ambitious effort to specify in a building code requirements for the indoor climate. It is hoped that they will prove to be a useful tool for designing energy-efficient buildings while maintaining an indoor climate which provides acceptable comfort and does not impair human health.

REFERENCES

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*Radiant temperature asymmetry is the difference between the plane radiant temperature of the two opposite sides of a small element. Plane radiant temperature is the uniform temperature of an enclosure in which the incident radiation on one side of a small plane element is the same as in the existing non-uniform environment.