

# Indoor Air Quality Criteria

**Erhard Mayer**
**Fraunhofer Institute of Building Physics**
**(Director: Prof. Dr. Dr. h.c. mult. Dr. E.h. mult. Karl Gertis)**
**Postfach 1152**
**83601 Holzkirchen, Germany**
**Phone: +49-8024/643-14**
**Fax: +49-8024/643-66**

## Necessity for Indoor Air Quality Criteria?

The possible conflict between the
- must to reduce the heat loss of buildings (IEA-goal) and the
- must to provide good indoor air quality (IAQ, for health aspects)

is described detailed in a recent European Commission publication [1]. Some of the main conclusions are as follows.

1. Both the rational use of energy and provision of good IAQ are important aspects of building design and refurbishment. There are potential conflicts between these requirements. The impact of possible energy saving measures on IAQ should always be discussed before their eventual adoption and if unacceptable, these measures should be avoided.

2. Source control should be the first priority.

3. Ventilation requirements should be determined considering the total pollutant load present in a building as the result of building constituents, occupants and their activities. The goal of ventilation should be to provide good IAQ and satisfaction for occupants. A secondary goal is to protect the building, installations and furnishings.

4. The recommended strategy for designing new buildings and refurbishing existing buildings taking both IAQ and energy into account (there may be some restriction of choice in existing buildings) is:
   - control sources of pollution and of energy loss by using suitable materials, sealing, local extraction, etc.
   - determine ventilation strategy and design ventilation systems using energy-efficient and passive technologies where appropriate

- base the design of energy systems on the required ventilation rate
- design systems for IAQ and energy control to match the abilities for the occupants and users
- design systems for easy commissioning, maintenance and control.

5. The potential cost to society of poor indoor air quality is high. Remedial action to obtain good indoor air quality is likely to be cost effective even if an expensive retrofit is required. Much knowledge is already available and this needs to be put to better use by more effort on information transfer and coordination by those involved in the design process.

According to these statements there is a clear demand for indoor air criteria which will be relevant for source control and adequate ventilation of buildings as well. The background and definition of such criteria are described in the next paragraph.

## Background and Definition for Newlindoor Air Quality Criteria

From Pettenkofer in the 1800s [2] to Yaglou in the 1930s [3] until the 1980s people appeared to be the only pollution sources in rooms. Consequently, carbondioxide as indicator gas for human bioeffluents was a measure for IAQ. This still is valid for low polluted buildings, see figure 1. This figure proves the tight correlation between carbondioxide concentration, bioeffluents and olfactory sensation. And still the Pettenkofer value of about 0,1 % (0,15 %) carbondioxide is recognised as threshold value for polluted air - when people are the only pollution source.

It is Fanger's merit to stress that air pollution in buildings which can be realised by olfactory sensation is not caused only by people. In the 1980s he found out that those emissions of building materials including HVAC-components can pollute the air and consequently health effects are supposed, at least correlations to the sick building syndrome (SBS) [4].

An unit of odour emission was defined [4, 5] as the emission rate of air pollution caused by a standard person (bioeffluents) of '1 olf' (derived from *olfactus*, sense of smell). This unit is caused by a sitting adult person in thermal neutrality with an average hygienic standard (0,7 baths per day and a daily change of underwear). It is crucial that the unit of reference as well as other emission rates - for example 25 olf for a smoker in the act of smoking - cannot be traced by technical instruments but only by the human nose.

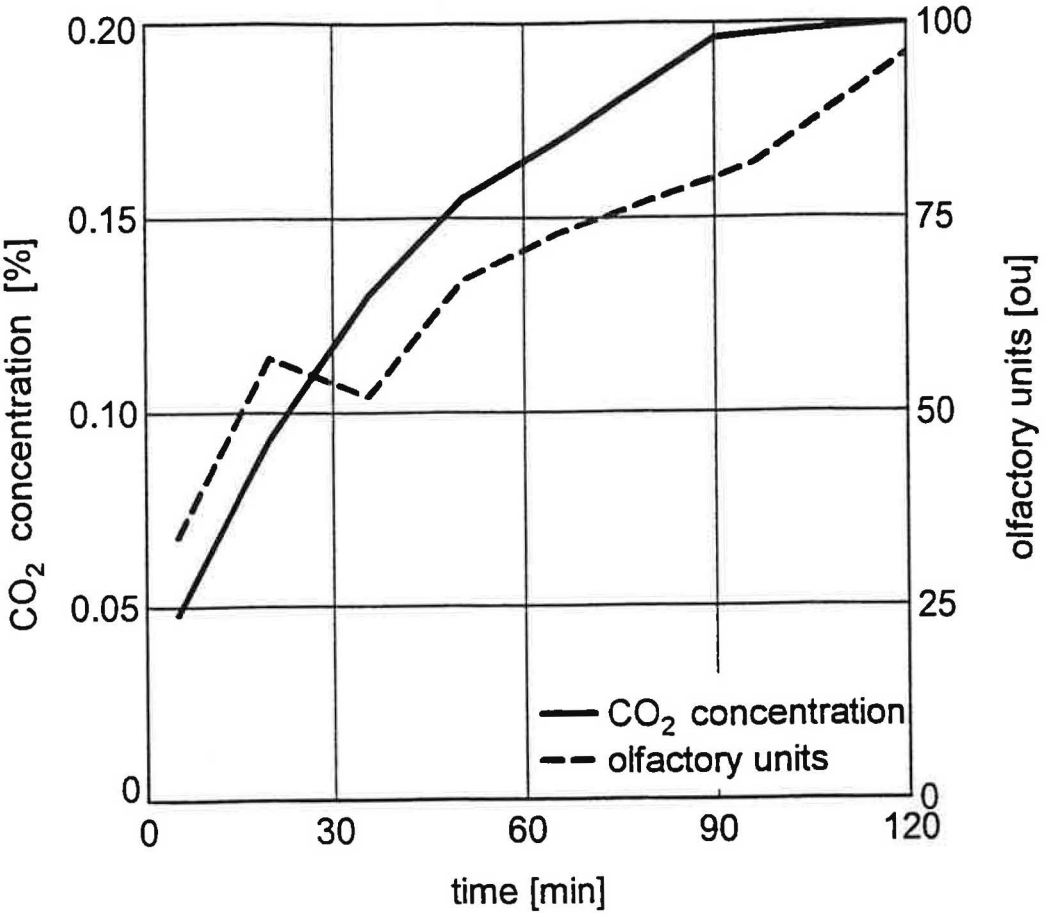


Figure 1: Carbondioxide concentration and olfactory intensity during two hours, when four sitting persons in a room were the only pollution source. The room of 30 m³ volume was ventilated by 24 m³ per hour [13].

More precisely: the rating scale for a certain emission rate is the percentage of persons dissatisfied with the indoor air, directly after entering the room in question. Figure 2 illustrates this fact. The number of dissatisfied people is measured against a fixed odour rate and the outdoor air exchange (ventilation rate). These results were based on extensive measurements with more than a thousand standard persons in a room with different ventilation rates and 168 persons who carried out the evaluations. Therefore, it is likely that in a room with one person and an air exchange rate of 10 l/s, 15 of 100 persons will find the air unacceptable.

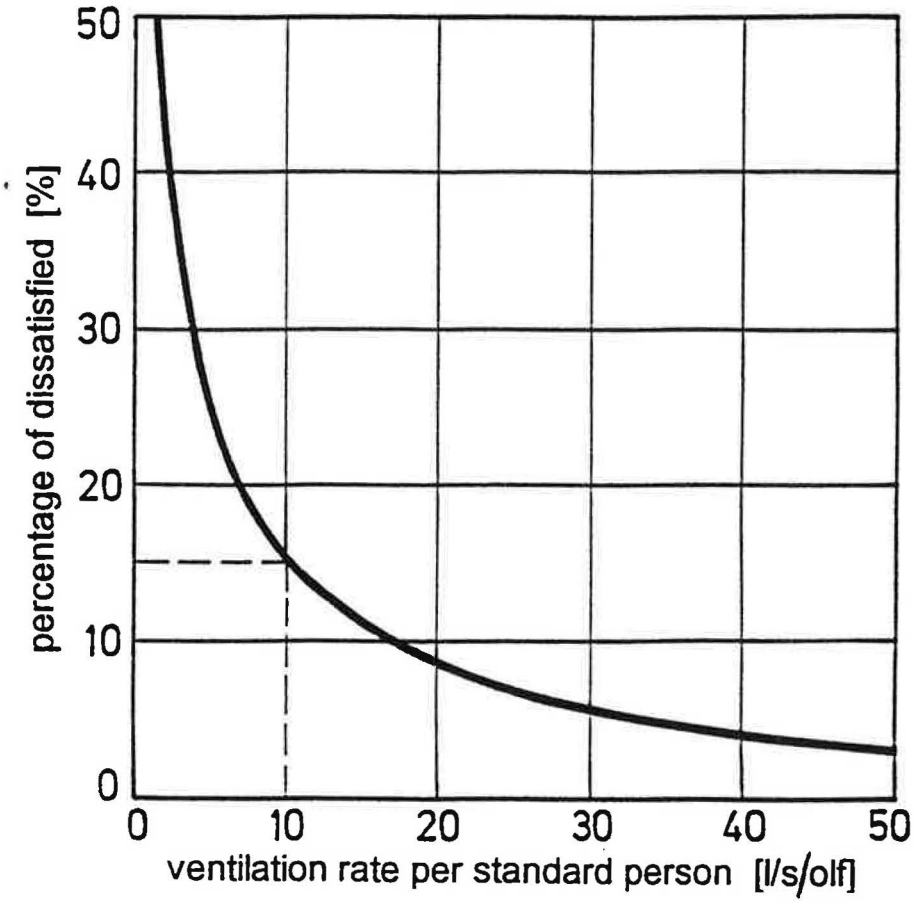


Figure 2: Dissatisfaction due to the estimated air quality which is based on the dependence of the ventilation rate of 1 olf. The basis for the curve are subjective evaluations from 168 participants in a room with more than a thousand people [5].

Fanger also designated an immission rate of the perceived air quality according to the percentage of dissatisfied persons. The corresponding unit is the decipol. With a ventilation rate of 10 l/s and the emission of one olf, that is 0,1 olf /(l/s) the immission rate amounts to 1 decipol. Thereby, as stated above, 15 % of dissatisfied persons are to be expected. Figure 3 states the correlation of estimated air quality and the percentage of dissatisfied persons. The graph in figure 3 is directly derived from figure 2.

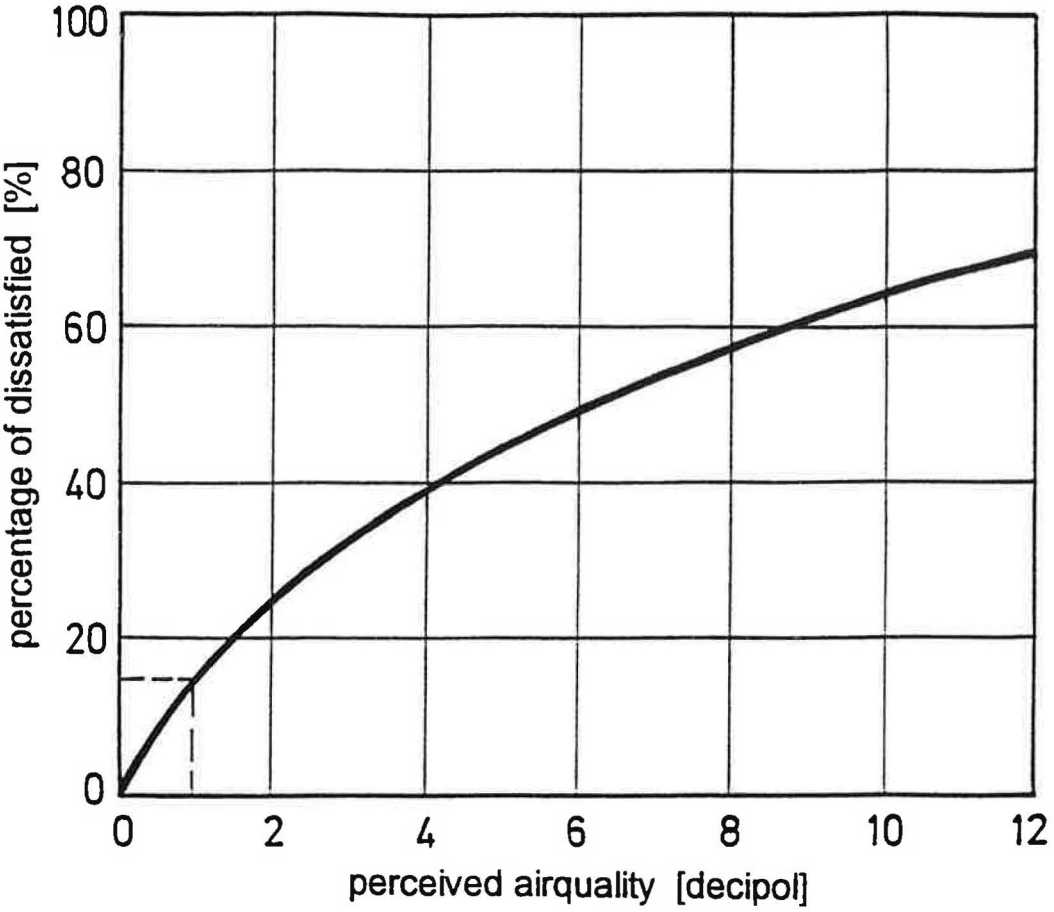


Figure 3: Dissatisfaction in dependence of the estimated air quality, derived from figure 2 [5].

According to these results instead of the Pettenkofer-value, new IAQ-criteria can be formulated, which are discussed in the next paragraph.

## European Standard taking into Account the New Indoor Air Quality Criteria

Within the European CEN standardisation activities the Working Group 6 of TC156 (Ventilation of Buildings) elaborated the draft prestandard prENV 1752 "Design Criteria for the Indoor Environment" [6]. Besides acoustical and thermal comfort requirements it mainly deals with IAQ. There are three levels of IAQ proposed, corresponding to three categories of perceived air quality:

A, high quality: 15 % dissatisfied
B, mean quality: 20 % dissatisfied
C, low quality: 30 % dissatisfied

Table 1 offers the correlations between these three categories, the perceived air quality expressed by % of dissatisfied and the decipol-values as well as an example for the required ventilation rates within offices - where clean outdoor air and a ventilation effectiveness of one are assumed. The mentioned ventilation rates would be valid for low-olf buildings of less than 0,1 olf/m² pollution. For not low pollution buildings extra ventilation rates of 0,4, 0,7 and 1,0 l/s·m² have to be added. And that is the philosophy behind the new standard: not to increase the ventilation rate but to force the designer to use low polluting building materials and ventilation systems.

Table 1: Three categories of perceived indoor air quality as proposed in prENV 1752 [6].

| Category | Perceived air quality | | Required ventilation rate for offices (landscape) |
|---|---|---|---|
| | [% dissatisfied] | [dp] | [l/s · m² floor] |
| A | 15 | 1,0 | 1,7 |
| B | 20 | 1,4 | 1,2 |
| C | 30 | 2,5 | 0,7 |

**Outlook**

It is true that the new IAQ criteria are not already accepted by everybody. The main reasons for that are lacking pollution data and minor acquaintance with evaluation methods of perceived air quality. But that there exists a clear trend, is proven by the facts that in Germany a similar standard exists already: DIN 1946 part 2 [7] and that within a running European project pollution data (perceived, chemical and toxicological) of materials are systematically collected: the project "European Data Base on Indoor Air Pollution Sources in Buildings" [8 to 11], similar to a few years project in Germany, started 1996 by Fraunhofer-Institut für Bauphysik and Institut für Toxikologie und Umwelthygiene, Technical University Munich: the project "Gesundheits- und umweltverträgliche Bauprodukte" [12].

## Literature

[1] European Concerted Action 'Indoor Air Quality and its Impact on Man: Indoor Air Quality and the Use of Energy in Buildings'. Report No 17, EUR 16367 EN, Luxembourg, Office for Official Publications of the European Communities (1996).

[2] Pettenkofer, M.V.: Über den Luftwechsel in Wohngebäuden. Literarisch-Artistische Anstalt der J.G. Cotta'schen Buchhandlung, München (1858).

[3] Yaglou, C.P.; Riley, E.C., Coggins, D.I.: Ventilation requirements. ASHRAE Transactions 42 (1936), P. 133-162.

[4] Fanger, P.O.: A Solution to the Sick Building Mystery. INDOOR AIR '87, Berlin (1987), Volume 4, P. 49-55.

[5] Fanger, P.O.: A Comfort Equation for Indoor Air Quality and Ventilation. Healthy Buildings '88, Stockholm (1988), Volume 1, P. 39-51.

[6] European prestandard, prENV 1752. European Committee for Standardization, Brussels (1994).

[7] DIN 1946, Teil 2, Raumlufttechnik, Gesundheitstechnische Anforderungen. Beuth-Verlag Berlin, Januar 1994.

[8] Clausen, G.; Fernandes, O.: Newsletter No. 1, European Data Base on Indoor Air Pollution Sources in Buildings. European Commission, Directorate General XII for Science, Research and Development, Programme Joule II, December 1994.

[9] Clausen, G.; Fernandes, O.: Newsletter No. 2, European Data Base on Indoor Air Pollution Sources in Buildings. European Commission, Directorate General XII for Science, Research and Development, Programme Joule II, May 1994.

[10] Clausen, G.; Fernandes, O.: Newsletter No. 3, European Data Base on Indoor Air Pollution Sources in Buildings. European Commission, Directorate General XII for Science, Research and Development, Programme Joule II, May 1995.

[11] Clausen, G.; Fernandes, O.: Newsletter No. 4, European Data Base on Indoor Air Pollution Sources in Buildings. European Commission, Directorate General XII for Science, Research and Development, Programme Joule II, December 1995.

[12] Fraunhofer-Gesellschaft Press Service: Healthy living in healthy houses. Research News of Fraunhofer-Gesellschaft No. 12, Topic 5, München (1995).

[13] Huber, G.; Wanner, H.U.: Raumluftqualität und minimale Lüftungsraten. Gesundheits-Ingenieur - gi 103 (1982), H. 4, S. 207-210.