# VENTILATION AND BACKGROUND ODOR IN OFFICES

J.Lauridsen, M.Muhaxheri, G.H.Clausen and P.O.Fanger
Laboratory of Heating and Air Conditioning
Technical University of Denmark

## Abstract

Ventilation standards assume that the occupants are the major polluters in offices and conference rooms.

In the present field study 49 judges (visitors) evaluated the odor intensity, air freshness and acceptability of the air in 15 different offices and 5 conference rooms at three different occasions: a) with no mechanical ventilation and no occupants, b) with mechanical ventilation and no occupants, and c) with mechanical ventilation and with occupants.

Preliminary results imply that the background odor is an important characteristic of indoor air quality. It should be taken into account by modelling ventilation requirements.

## Introduction

In general, perceived odor in a room is caused by the present activity and the background odor in the space. Clausen et al (2) stated that background odor mainly is a combination of desorbed substances from earlier absorbed pollution and volatile organic compounds from buildings materials, furnitures etc. In a field study in bars, restaurants and cantines a relation was found between background odor and the history of tobacco smoking in the spaces.

Previous studies on ventilation requirements and tobacco smoke by Yaglou (4,5) and Cain et al (1) were performed in climate chambers with controlled environmental parameters and low or moderate levels of background odor. This gives some translation-problems in relation to real-life conditions where backgorund odor may be of the same magnitude as e.g. tobacco smoke odor.

The aim of this field study has been to identify the background odor in typical offices and conference rooms. The idea was to study the background odor with and without ventilation. Furthermore, it was planned to study the combined effect of background and odors from bioeffluents and tobacco smoke during normal occupancy of the spaces.

## Methods

The 15 offices and 5 conference rooms were selected among more than 30 spaces offered during an enquiry. For selection, the following three conditions had to be met: 1) the room area should exeed 62 $m^2$, to avoid any significant impact of the entering judges on the air quality in the space, 2) there had to be mechanical ventilation and it should be possible to run the system without recirculation, 3) a maximum of 3 adjacent rooms





were allowed with direct entrance to the room, due to the measuring technique for determining the air change with passive perfluorocarbon tracers, developed by R.Dietz et al (3). The offices/conference rooms were located less than half a minute's walking distance from the main entrance of each building. Occupants and other users of the room were told to behave as usual. Room data are shown in table 1.

In each of the 20 spaces the air change, the concentration of volatile organic compounds and the particulate matter indoor and outdoor were measured as a mean for a period of approximately 4 hours. The organic compounds were traced by pumping respectively 0.1-0.2 $m^3$ and 1-2 $m^3$ of air through two sets of charcoal tracer tubes (a qualitative and a quantitative sample). The tubes were later analyzed by gaschromatography. Particulate matter was measured by pumping 2.5-3.5 $m^3$ air through filter monitors (0.5 µm pore-size, 37 mm diameter, teflon). The mass of each filter was gravimetrically determined before and after sampling, under the same thermal conditions and with the filter monitors sealed before and after sampling.

Ten liters of the indoor and outdoor air were sampled into teflon bags at the time of evaluation. Within 6 hours the samples were analyzed in the laboratory for carbondioxide ($CO_2$) and carbonmonoxide (CO). Under conditions with mechanical ventilation no exhausted air was recirculated.

## Subjects

49 men and women (18-30 yrs, mean: 23 yrs), smokers and non-smokers served as odor judges. 31 of these subjects (18 men and 13 women) served as permanent judges throughout all six experiment days, while the rest joined for 5 or fewer days (mean: 3 days). All subjects were paid for their participation. No statistical significant differences were observed between responses of permanent and temporary judges (significance level 0.05), and the data were therefore pooled.

## Procedure

Each space was judged on three different days during the following three conditions: a) with no mechanical ventilation and no occupants, b) with mechanical ventilation and no occupants, and c) with mechanical ventilation and with occupants. The order of the three visits in each space was randomized. Ten spaces were judged on a Saturday, Sunday and Monday. The ten other spaces were judged on the following Friday, Saturday and Sunday.

The group was brought from place to place in a bus. When a group arrived to a place, half of them were asked to leave the bus and judge the outdoor air quality concerning odor intensity, acceptance and freshness. This took approximately half a minute. Immediately afterwards they were entering the actual office/conference room and they were asked to judge the indoor air quality in the same way, and then leave and return to the bus. The same procedure was repeated with the other half of the group. Both groups were guided at each visit. A visit lasted typically five munutes from the bus arrived until the bus left. The judges were instructed not to talk about the air quality or other conditions related

to the experiments. Before the first visit, the judges were familiarized with the questions and the use of the questionnaires.

## Results

The preliminary reesults of the physical and psycho-physical data are shown as mean values in table 2. The air temperature was maintained between 20 and 25 $^{o}$C, the relative humidity was between 32 and 56%. It is seen that during the the conditions of no occupance the concentration of carbondioxide and carbonmonoxide was negligible. In figs. 1-2 the intensity and the acceptance (expressed as percent of dissatisfied) are shown for each room and each experimental condition. It should be noticed in general that even though the level of intensity is rather constant the percent of dissatisfied varies within a large range The measurements on ventilation rates and volatile organic compounds are under analysis and will be reported in a later publication.

## Discussion

The study identifies the importance of background odor in office and conference halls. Even when the empty spaces were mechanical ventilated the background odor caused more than 20% dissatisfied in two thirds of the investigated spaces. When unventilated the background odor was even stronger and caused higher dissatisfaction. Occupance changed only slightly the odor intensity and dissatisfaction. The measured $CO_2$-concentrations show that the ventilation rate (per person) was high. The measured CO-contents in the room air show a low tobacco smoke concentration. In other cases in practice with more persons and heavier smoking, bioeffluents and tobacco smoking may contribute more to odor intensity and dissatisfaction than in the present field study. Still, it is obvious from this research that background odor will play an essential role for odor and human dissatisfaction. Another remarkable finding in the present study is the substantial variation in background odor from space to space. Differences in ventilation of the spaces may partly explain the variation. Another and likely reason may be differences in the odor sources. Further information on this may be available when the analysis of the air quality in the present field study is completed.

## Conclusions

- In offices and conference rooms background odor may contribute more to the odor level than bioeffluents or tobacco smoke produced by occupants.
- Further studies are recommended to identify the sources of background odor.

## Acknowledgement

This research was funded by the Danish Ministry of Housing.



## References

1. Cain, W.S., Leaderer, B.P., Isseroff, R., Berglund, L.G., Huey, R.J., Lipsitt, E.D., Perlman, D. Ventilation requirements in buildings: Control of occupancy odor and tobacco smoke odor. Atmospheric environment 17, 6 (1983).

2. Clausen, G.H., Møller, S.B., Fanger, P.O., Leaderer, B.P., Dietz, R.N. Background odor caused by previous smoking. Proc. of IAQ '86, Managing Indoor Air for Health and Energy Conservation, April 1986, Atlanta, USA.

3. Dietz, R.N. and Cote, E.A. Air infiltration measurements in a home using a convenient perfluorocarbon tracer technique. Environment International 8 (1982)

4. Yaglou, C.P., Riley, E.C. and Coggins, D.I. Ventilation requirements. ASHVE Transactions 42 (1936).

5. Yaglou, C.P. and Witheridge, W.N. Ventilation requirements (part 2). ASHVE Transactions 43 (1937).

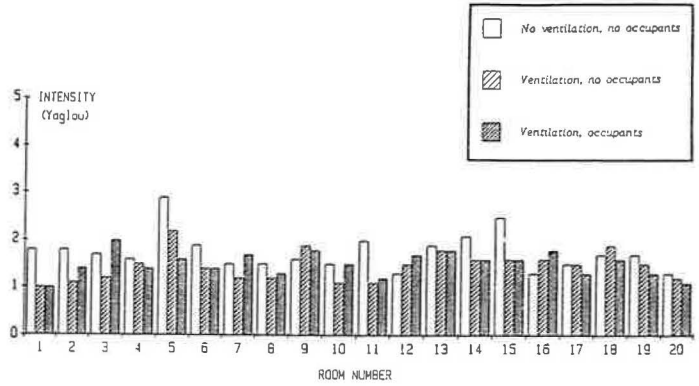


*Figure 1. Odor intensity in the twenty spaces.*

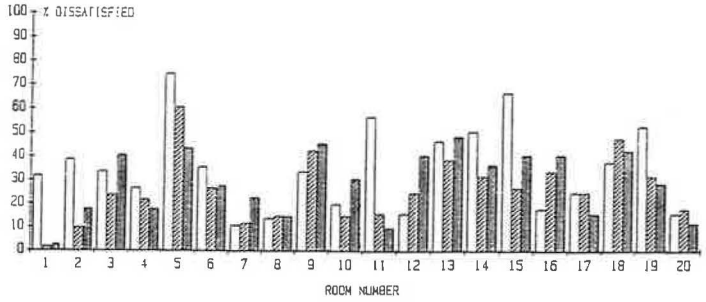


*Figure 2. Percentage of dissatisfied in the twenty spaces*

*Table 1: Characteristics of investigated spaces.*

| Room No | Type | Area ($m^2$) | Vol. ($m^3$) | Max. No. of occup. | Age of room (yrs) | Time since last renovation (yrs) |
|---|---|---|---|---|---|---|
| 1 | Auditorium | 200 | 1150 | 100 | 16 | 16 |
| 2 | Office | 180 | 459 | 12 | 15 | 3 |
| 3 | Office | 375 | 956 | 22 | 15 | 15 |
| 4 | Office | 129 | 340 | 10 | 14 | 14 |
| 5 | Office | 321 | 964 | 7 | 24 | 3 |
| 6 | Conference room | 60 | 157 | 13 | 2 | 2 |
| 7 | Office | 152 | 463 | 14 | 16 | 16 |
| 8 | Office | 181 | 551 | 17 | 16 | 16 |
| 9 | Office | 105 | 263 | 7 | 10 | 3 |
| 10 | Office | 163 | 461 | 13 | 24 | 1 |
| 11 | Conference room | 119 | 292 | 39 | 3 | 3 |
| 12 | Office | 136 | 347 | 9 | 12 | 12 |
| 13 | Office landscape | 928 | 3480 | 55 | 11 | 11 |
| 14 | Office | 143 | 371 | 28 | 12 | 12 |
| 15 | Office | 265 | 954 | 25 | 12 | 2 |
| 16 | Office | 121 | 322 | 12 | 14 | 4 |
| 17 | Office | 106 | 275 | 7 | 14 | 2 |
| 18 | Office | 150 | 644 | 18 | 26 | 10 |
| 19 | Movie theatre | 150 | 563 | 40 | 10 | 10 |
| 20 | Auditorium | 123 | 627 | -* | 45 | 10 |
| | Total Mean | 205 | 682 | 24 | 16 | 8 |

*) Not occupied during experiment

*Table 2: Mean value of physical and psycho-physical measurements in 20 spaces.*

| Condition | | $CO_2$ above outdoor (%) | CO above concentrat. (ppm) | part. above ($\mu g/m^3$) | odor intensity (Yag.)* | indoor dissatisfied (%) | freshness (-)** | odor intensity (Yag.)* | outdoor dissatisfied (%) | freshness (-)** |
|---|---|---|---|---|---|---|---|---|---|---|
| No ventilation No occupants | Mean | 0.005 | 0.0 | -19 | 1.8 | 36 | -0.5 | 0.6 | 1 | 0.8 |
| | S.D. | 0.006 | 0.0 | 23 | 0.4 | - | 0.3 | 0.2 | - | 0.3 |
| Ventilation No occupants | Mean | 0.001 | 0.0 | -17 | 1.5 | 26 | -0.4 | 0.6 | 4 | 0.8 |
| | S.D. | 0.003 | 0.1 | 11 | 0.3 | - | 0.3 | 0.3 | - | 0.3 |
| Ventilation Occupants | Mean | 0.030 | 0.3 | 27 | 1.5 | 30 | -0.4 | 0.9 | 9 | 0.6 |
| | S.D. | 0.018 | 0.2 | 43 | 0.2 | - | 0.2 | 0.5 | - | 0.4 |

*) Range: [0; 5]

**) Range: -2, -1, 0, 1, 2



# POSTER SESSION

## Odours, Irritants and Formaldehyde