PAPER 3

# INDOOR AIR QUALITY AND MINIMUM VENTILATION

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## INTRODUCTION

Energy conservation efforts of past years have directed the attention towards heat losses due to ventilation. In this connection studies on indoor air quality became more important. Improved insulation of cracks and slits of doors and windows as well as the reduced operation of eventually available forced ventilation systems have led to reduced air exchanges and hence to the considerable reduction in supply of fresh air. From the hygienic point of view the questions are raised as to what are the effects of such measures on indoor environment and what are the minimum ventilation rates necessary in order to fulfil the hygienic requirements of indoor air quality.

The first part of this paper deals with an overview on important sources of indoor air pollutants. The second part discusses the ways and means of measuring the contaminants emitted by the very presence of man in a room (carbon dioxide and odors). Based on our own investigations we have made some recommendations on minimum ventilation rates or minimum supply of fresh air.

## MAN AS A SOURCE OF AIR POLLUTION

Pollution of indoor air where the sources themselves are indoors depends on the furnishing of the room and the activities therein. Here one should concentrate on decomposition of building materials and their long-term effect due to daily exposure (WANNER, 1980). The effect on indoor air quality by man himself is not only due to his actions like smoking and cooking. Depending upon his activities the air quality will be affected by the temperature, the relative humidity, carbon dioxide concentrations, viable and nonviable particles emitted by the skin as well as perspiration - depending upon what he does in that room (BRUNNER, 1977). The number of persons in a given room or the space per person, and the supply of fresh air determine the effects of these parameters.

The subjective assessment of indoor air pollution caused by man can best be made by odors and objective assessment simply by carbon dioxide. Concentration of carbon dioxide in ambient air lies between 0.03 and 0.04 % which can reach up to double of this value in cities and in industrial areas. In European countries we have a recommended level of maximum 0.1 % $CO_2$ in indoor air of living places (so-called Pettenkofer-Number), and in some cases even 0.15 % $CO_2$ (BORNEFF 1974, RIGOS 1981). In the USA the MAC value of 0.5 % for workplaces is applied for the indoor air in living places as well (ASHRAE, 1980). Reduction of this limit to 0.25 % is under discussion.

## METHODS OF MEASURING CARBON DIOXIDE AND ODOR

Primary aim of this investigation was to study carbon dioxide and odor pollution caused by man. Carbon dioxide was measured by physical infrared method of gas analysis. Odor was measured by sensory method whereby selected test panel evaluated the instantaneous odor situation in our odor intensity measuring apparatus called GIMA (HUBER 1981 a). Here the perceived odor intensity of the air sampled from a test-chamber is compared with the odor intensity of reference substance pyridine at a known concentration. So-called annoyance level indicated the threshold limit of a substance above which its odor is perceived as a disturbing one.

## TESTS AT STANDARD CONDITIONS

Twentyone runs were made in a test-chamber of 30 $m^3$ volume (little more than 1000 cubic feet) by changing the following variables:

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|---|---|
| - Number of persons: | 1, 2, or 4 (in other words, space volume per person: 30, 15, or 7,5 $m^3$, or about 1000, 500, and 250 cft) |
| - Activity of persons: | Rest (50-70 W),<br>Bicycle ergometer (250 W) |
| - Air exchange rate: | 0.1, 0.2, 0.8, or 1.6 per hour |

Each run took two hours and bicycle ergometer was used for 45 minutes. Odor intensity of the indoor air was evaluated at every 15 minutes. Temperature, relative humidity, and carbon dioxide concentrations were monitored continuously.

## RESULTS AND CONCLUSIONS

Figure 1 shows carbon dioxide concentrations as a function of time and perceived odor intensity. Correlations between carbon dioxide concentrations and odor intensities for all the twentyone runs are shown in Figure 2 (HUBER 1981 b).

From the results of this study it can be concluded that in the rooms where no smoking is allowed, with space volume of about 12 - 15 $m^3$/person, at a carbon dioxide concentration of more than 0.15% an increase of annoyance due to odor can be expected. This limit of 0.15% $CO_2$ can be maintained in the rooms by supplying the fresh air of usual $CO_2$ content of 0.03 - 0.04% at the rate of 15 $m^3$/h/person assuming that only light physical work is performed in the rooms.

This relationship between $CO_2$ and perceived odor intensity is not valid for the rooms where smoking is permitted. In order to ensure satisfactory air quality in such rooms, one must reckon with fresh air supply of double the above quantity (WEBER, 1981).


ABSTRACT

In a test-chamber the carbon dioxide and the odor intensity were measured as function of room occupancy and ventilation rate. When the supply of fresh air was 12 - 15 $m^3$ per person per hour, the carbon dioxide concentration was less than 0.15 % and the odor intensity was evaluated only as "slight annoyance". Higher ventilation rates are necessary if increased physical activities and smoking is done in the rooms.


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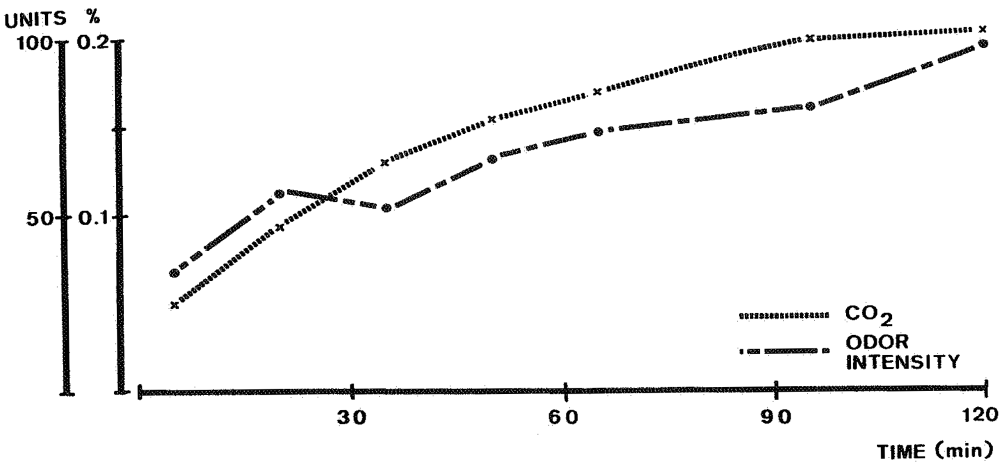


Figure 1: Carbon dioxide concentration and odor intensity as a function of time. Odor intensity was evaluated at the interval of 15 minutes during first hour and 30 minutes during second hour. Test conditions: 4 persons sitting in a room of 30 $m^3$ volume with air exchange rate of 0.8 (corresponding to the supply of fresh air at the rate of 6 $m^3$ per person per hour).

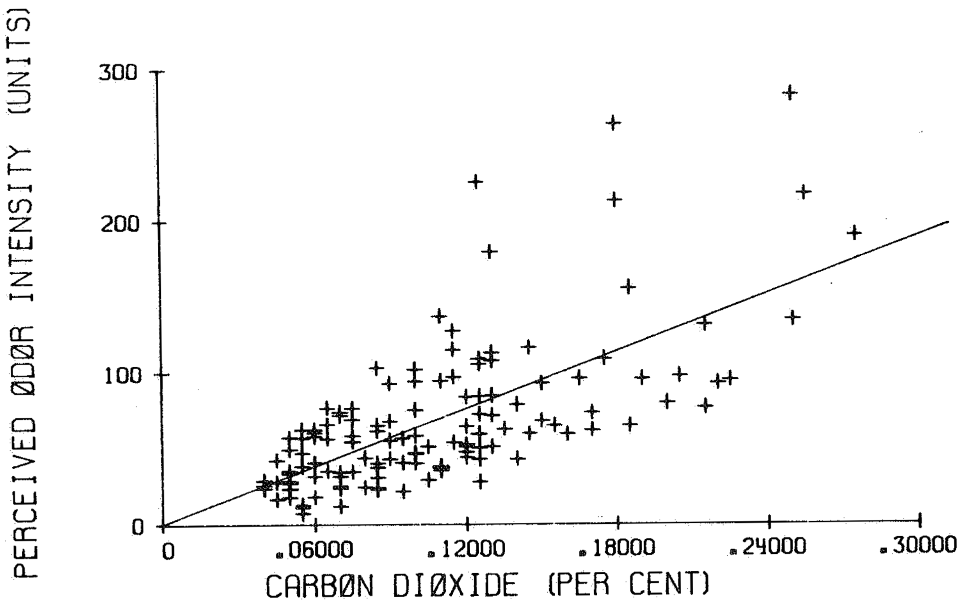


Figure 2: Relation between carbon dioxide concentration (in percent) and perceived odor intensity (100 units are equivalent to a reference odor of 365 ppb pyridine). Investigation in a test-chamber with variable occupancy and ventilation rates.