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Indoor Air Quality and Minimum Ventilation Rate

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Introduction

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

In this paper, we give first a short review on the most important sources of indoor air pollutants, then the possibilities for measuring the contamination of room air by persons (carbon dioxide and odours) will be described, and finally we list some recommendations for the minimum fresh air rates. These recommendations are based on experimental investigations which are referred to in another study.[1] The most important results of this study have been integrated in the present paper.

Sources of Indoor Air Pollution

The sources of pollutants which contaminate indoor air at workplaces as well as in residential quarters can be classified into two groups, shown in Figure 1. On the one hand we have the pollutants from ambient air or outdoor air which gets indoors by natural or by forced ventilation; the main sources outdoors which can influence the quality of air indoors are streets with heavy traffic density, industries and house heating equipment. On the other hand there are some sources of air pollutants which happen to be indoors themselves. Furnishing a room and using it, plays an important role. Emission products of modern building materials demand special attention here.

This article deals with the indoor air pollution caused by *man alone*. Subjectively, such pollution can best be assessed through odours and objectively by measuring the carbon dioxide in the room. Concentration of carbon dioxide in ambient air lies between 0.03 and 0.04%; this percentage can be double in cities and in industrial areas. In some European countries we have a maximum recommended level of 0.1% CO_2 in indoor air of living places (so called Pettenkofer-Number), and in some cases even 0.15% CO_2. In the USA a limit of 0.25% CO_2 is taken for general ventilation standards, leaving an additional safety factor covering individual activities, diet and health variations.[2]

Methods of Measuring Carbon Dioxide and Odour

The carbon dioxide was measured by means of an infrared gas analyzer ('URAS-2'). The evaluation of instantaneous odour was effected by sensory perception, i.e. through subjective odour intensity assessment carried out by test persons. For this purpose it was necessary to develop an apparatus capable of conveying the relatively weak odours emanated by the people in the test-room to a group of four especially selected test-persons for their assessment.

Using the glass/teflon odour intensity measuring instrument GIMA, it was possible to present not only odours from the test-room itself, but also reference odours of known Pyridine concentrations for assessment. This method made it possible to register mixed odours of unknown concentrations in a semi-quantitative manner.

Further details of the GIMA apparatus and for the determination of the odour intensity are described in full in other papers[3,1]

Tests at Standard Conditions

18 runs were made in a test-chamber of 30 m³ volume. Each run took two hours. The odour intensity of the test-chamber was evaluated every 15 minutes. Temperature, relative humidity and carbon dioxide concentrations were monitored continuously. The variables in the test runs were number of persons (1, 2 or 4), space volume per person (30, 15 or 7.5 m³) and air exchange rate (0.1, 0.2, 0.8 or 1.6 per hour). For each of these variables there are 2 to 3 runs (total 18).

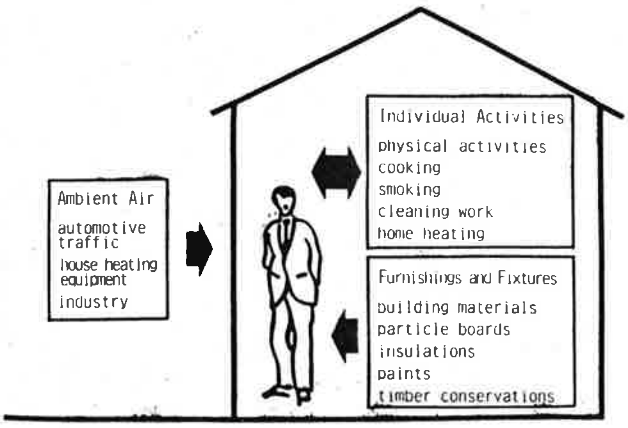

Figure 1: Sources of Indoor Air Pollution. Furnishings and fixtures could emit contaminants over a long period of time. The pollution load caused by individual activities depends on the occupancy and the use of the room. The contribution of the outdoor air depends upon the location of the building.

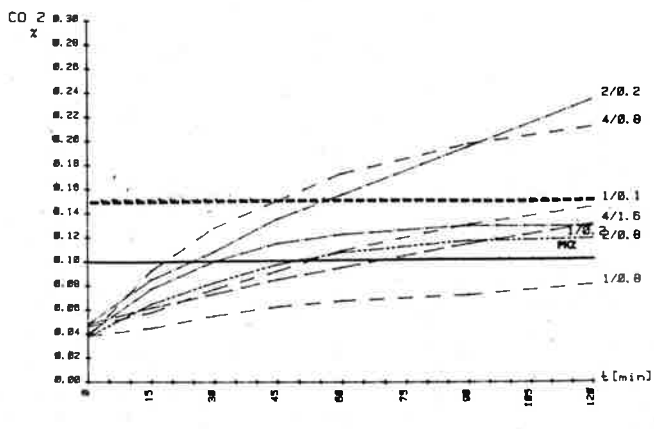

Figure 2: Duration of the carbon dioxide concentration in the room air of the test chamber. Variables: Persons (1, 2, 4) and air exchange rate per hour (0.1, 0.2, 0.8, 1.6). Each PKZ = Pettenkoferzahl of 0,1% CO_2.

The concentration of the carbon dioxide content in the air during the test runs is represented in Figure 2. The measurements were effected at the same intervals as the determination of odour annoyance (every 15 min). The curves show that carbon dioxide concentrations of 0.15% are exceeded after approximately 1 hour in 2 of the tests (2 persons, air exchange 0.2/h and 4 persons, air exchange 0.9/h).

The odour intensity assessed by test persons is shown in Figure 3. Although strong deviations occur, there is a distinct tendency which can be derived from the curves, i.e. the higher the number of persons and the smaller the air exchange rate, the stronger is the odour intensity assessed. The intensity of 80 'odour units', which has been indicated by test persons as 'acceptable', is not exceeded in the tests with 1 person alone in the climatic chamber; with 2 and 4 persons respectively, this threshold is exceeded after 60–90 minutes.

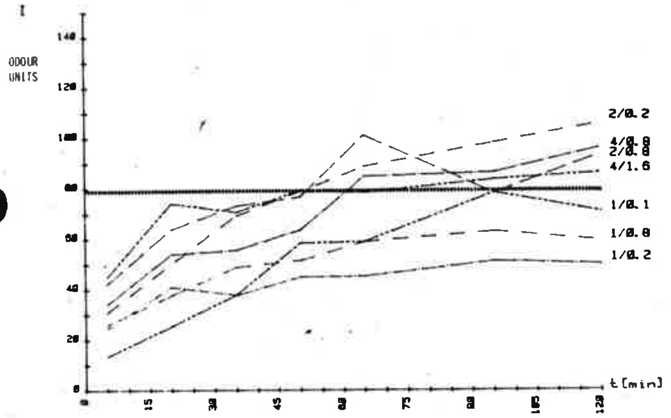

Figure 3: Duration of assessed odour intensity in the room air of the test chamber. The test persons evaluated the intensity of 100 'odour units' as the concentration of 365 ppb Pyridine. Odour intensities up to 80 'odour units' were assessed as 'acceptable'. Variables: Persons (1, 2, 4) and air exchange rates per hour (0.2,/.4,/.8, 1.6). Each curve is an average value of 2–3 runs.

The comparison of the curve relating to the odour intensity with that of carbon dioxide concentrations shows that there are connections between these 2 parameters. Such a relation is of a high practical value as, based on a relatively easy realisation of the carbon dioxide measurements, statements on a momentary odour situation in a room can be made.

Conclusions

Recommendations for a minimum ventilation rate or minimum fresh air supply based on this study are shown in Figure 4. The determining criterion is that the CO_2 concentration of 0.15% or the corresponding odour level of 80 odour-units should not be exceeded. Based on this curve, for a space volume of 15 m^3 per person, a minimum fresh air supply of 12 to 15 m^3 per person per hour is required. With the chosen duration of 2 hours for the tests, the 'space volume' also has an influence: at a space volume higher than 15 m^3 the fresh air supply rate will be lower and vice versa. But fresh air supply per person per hour should not be lower than 10 m^3 and the space volume per person should not be lower than 5 m^3.

For tests of a longer duration, the influence of the 'space volumes' would only be of minor importance, e.g. at an air exchange rate of 0.2/h, there will be stabilization after approximately 4 hours. However, in practice such a situation rarely occurs.

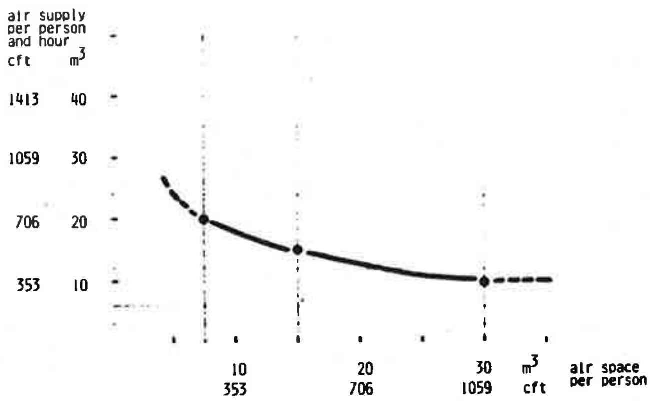

Figure 4: Minimum ventilation rates or minimum fresh air supply rates. Recommendations for a minimum ventilation rate can thus be worked out from CO_2 content of indoor air and the perceived odour intensity. The recommendations are based on values established after a test of 2 hours.

These recommendations are valid only for rooms where smoking is not permitted and where there is no other source of odour. The relationship between CO_2 and the perceived odour intensity derived in this study is not applicable for rooms where smoking is permitted. In order to ensure satisfactory air quality in such rooms one must allow for a fresh air supply of twice to four times the above-mentioned rate. Similarly the ventilation should also be increased in the rooms where work with physical activities is being done. Here the supply of fresh air should be adjusted to the demands of air quality required by the type of activities.

References

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