OCCUPANT INTERACTION WITH VENTILATION SYSTEMS

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PAPER 4

OCCUPANTS' INFLUENCE ON AIR CHANGE IN DWELLINGS

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Synopsis

The occupants' behaviour is one of the parameters which has the greatest influence on the air change in the dwelling. This applies both to naturally and to mechanically ventilated dwellings. On the basis of continuous measurement of the air change in 25 dwellings, the relation between the ventilation system and air change and between the number of occupants and air change is discussed. The air change in the 25 dwellings has been measured for a period of about one week during occupancy. The measuring principle applied is "the method with constant concentration of tracer gas". Even though the average air change for occupied dwellings is higher than the rate normally recommended in Denmark, some 20% of the dwellings have, nevertheless, an extremely low rate of air change. Only a small percentage of the dwellings have ventilation systems that can be adjusted to provide the desired rate of air change. The mechanical ventilation system usually gives too high a rate of air change, while the natural ventilation system usually provides too low a rate. Improved control of the total air change would achieve both energy savings and a better indoor climate.

Introduction

Previously it was the weather that had the greatest influence on the air change in the dwellings, but today it is left more up to ourselves to regulate this.

The influence of the outdoor climate on the air change has decreased concurrently with the dwellings becoming better tightened, and the holes remaining in the climate screen are today inadequate to produce the required degree of air change in the dwellings.

How do we solve the problem of ventilation and how good are the occupants at adjusting the air change according to their needs? These questions will be discussed on the basis of air change measurements in 25 occupied dwellings.

Measuring Method

The air change in each of the 25 dwellings was measured continuously during approx. one week with computer controlled measuring equipment. The measuring method applied was the "constant concentration of tracer gas".

The principle behind measuring with "constant concentration of tracer gas" is that a constant concentration of tracer gas is maintained in the rooms that are to be measured. The air change rate is then determined on the basis of how much tracer gas has to be let into the rooms to maintain the

original concentration. We used the tracer gas SF_6 and the concentration in the rooms was maintained at 5 PPM.

In order to ensure that the dwellings could be used normally as regards closing of internal doors, measuring points were placed in each room in the dwelling. This also makes it possible to measure in which rooms the outdoor air enters the dwelling.

Composition of the Measurement Group

Of the 25 dwellings in the measurement group, 16 were equipped with natural ventilation, 3 with mechanical exhaust systems and 6 with both injection and exhaust systems. In most of the naturally ventilated dwellings there were vents from bathroom, toilet and kitchen.

Classifying the measurement according to type of building, it is seen that there were 9 measurements in apartment blocks of more than 12 storeys and 16 measurements in housing units of 1 or 2 storeys. No measurements were conducted in medium-rise apartment blocks.

The average size of the dwelling was 104 m^2, while the average number of occupants was 2.8 - roughly corresponding to the national average for Denmark.

The mean room temperature for the measurements was 21°C; the outdoor temperature 1°C; and wind velocity 4.9 m/sec. The outdoor temperature was slightly lower and the wind velocity higher than the average values for the heating season in Denmark.

Influence of the Occupants

In the article, air change rates measured in occupied dwelling are designated "total air change" and air change rates measured in locked up, unoccupied dwellings are designated "basic air change" (outdoor valves, doors, windows and ventilation systems closed).

As it is not possible to measure the basic air change and total air change rate at the same time, the basic air change rate is only measured once in each dwelling. The basic air change rate is measured for approx. 2 hours.

In figure 1 can be seen the influence of the users on the air change in the 16 naturally ventilated dwellings:

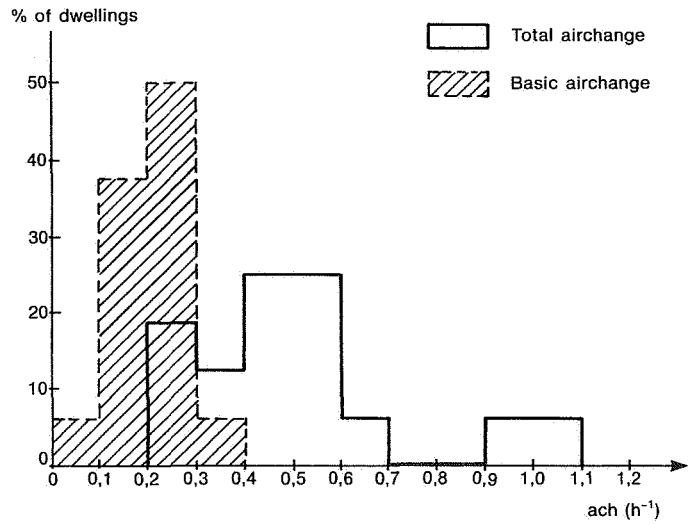

Fig. 1 Basic air change and average total air change for 16 naturally ventilated dwellings.

On average, the basic air change rate in the naturally ventilated dwellings is 0,19 times/h and the total air change rate 0.51 times/h, i.e. 63% of the total air change can be attributed to the behaviour of the occupants.

Even though the average total air change rate is close to the 0.5 times/h which is recommended in Denmark, the deviation in the values is so great that the air change in many of the dwellings is unacceptable. Over 30% of the naturally ventilated dwellings have a total air change rate of less than 0.4 times/h and in such a climate as Denmark's this will normally lead to problems with moisture.

In the mechanically ventilated dwellings, the air change is generally considerably higher than in the naturally ventilated dwellings. In fig. 2 the two ventilation systems have been compared.

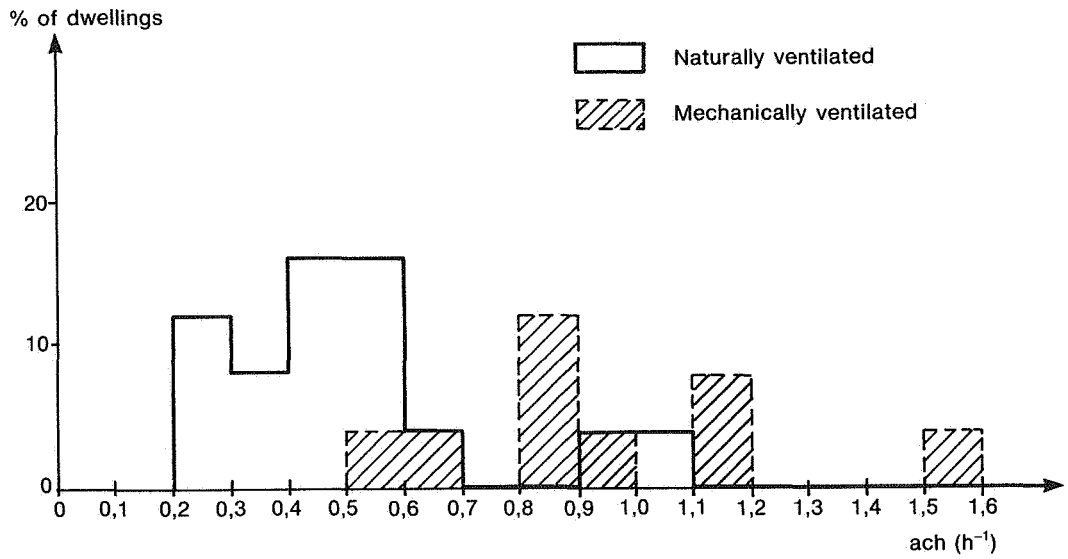

Fig. 2 Average total air change for the 16 naturally ventilated dwellings and the 9 mechanically ventilated dwellings.

The average total air change rate for the mechanically ventilated dwellings is 0.93 times/h, which is almost twice that of the naturally ventilated dwellings. Mechanical ventilation systems are normally dimensioned to provide all of the air change required. In addition to this there will always be a basic air change which depends on the tightness of the dwelling, influences from the climate and the ventilation system as well as an air change influenced by the behaviour of the occupants.

Calculated on the basis of the 6 dwellings where the dimension values for the ventilation system are known, the total air change turns out to be 70% higher than what was aimed at.

By looking at how the total air change varies according to time in a single dwelling, the occupant's influence on the air change can clearly be followed. In fig. 3 an example is shown of the variation of the air change for a one-family house with mechanical ventilation.

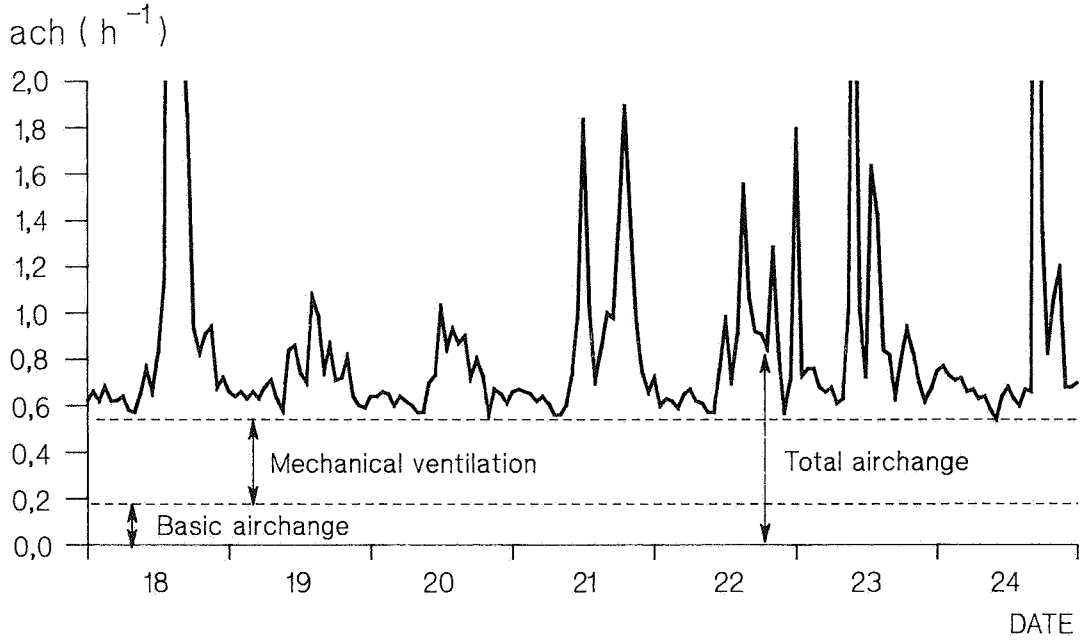

Fig. 3 The total air change as a function of time for a one-family house with mechanical injection and exhaust systems. The size of the basic air change and the performance of the ventilation system is shown on the figure.

The Behaviour of the Occupants

As is seen from figure 1, there is a considerable difference in the total air change between the individual dwellings. As the basic air change is fairly similar, it is the behaviour of the users which causes these large differences.

In order to get an idea of what influences the occupants' habits regarding ventilation and what is irrelevant, the following 4 assumptions have been tested for the 16 naturally ventilated dwellings:

- the total air change in times/h is a function of the number of occupants
- the total air change in m^3/h is a function of the number of occupants
- the total air change depends on the outdoor temperature
- the total air change depends on the room temperature

In figs. 4 and 5 the total air change rate can be seen as a function of the number of occupants; in fig. 6 as a function of the outdoor temperature; in fig. 7 as a function of the room temperature.

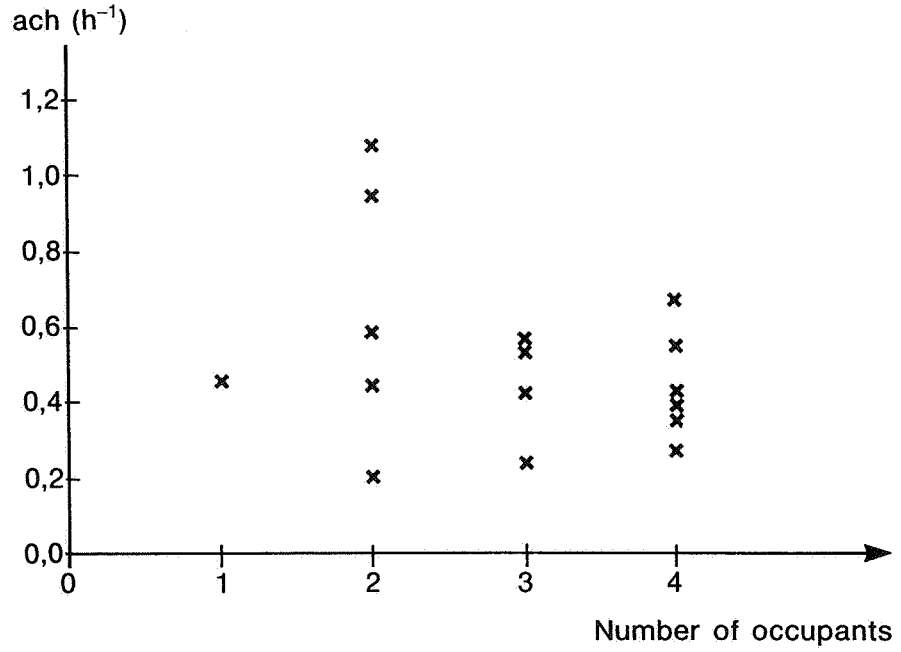

Fig. 4 Average total air change as a function of the number of occupants for the 16 naturally ventilated dwellings.

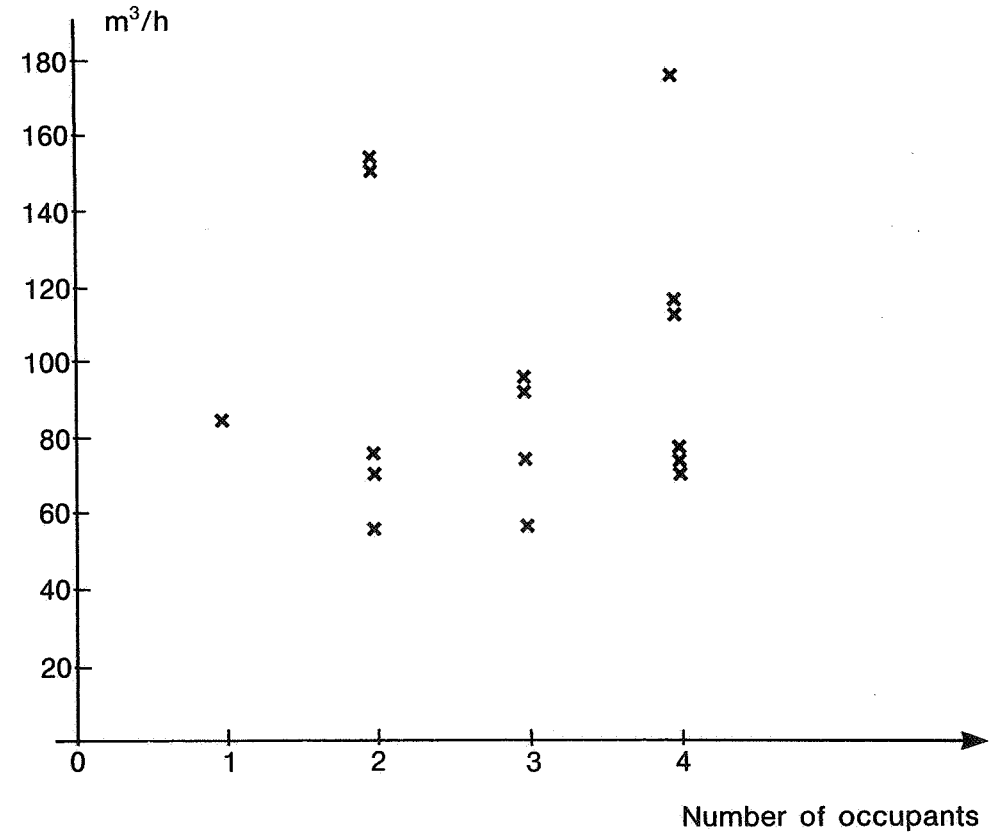

Fig. 5 Average total air change as a function of the number of occupants for the 16 naturally ventilated dwellings.

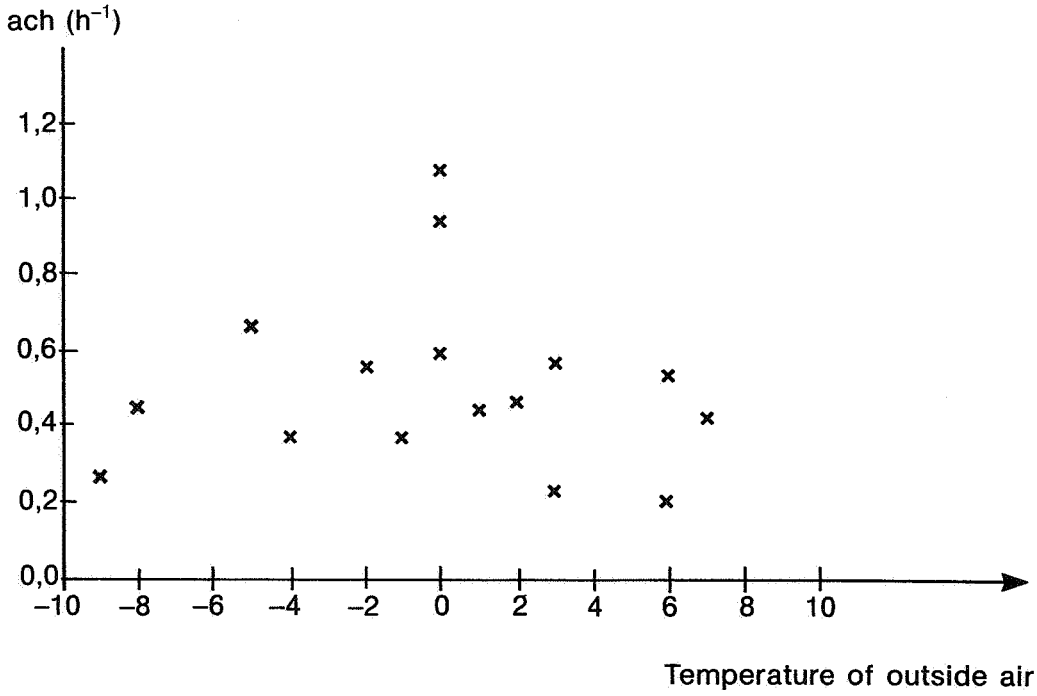

Fig. 6 Average total air change as a function of the outdoor temperature for the 16 naturally ventilated dwellings.

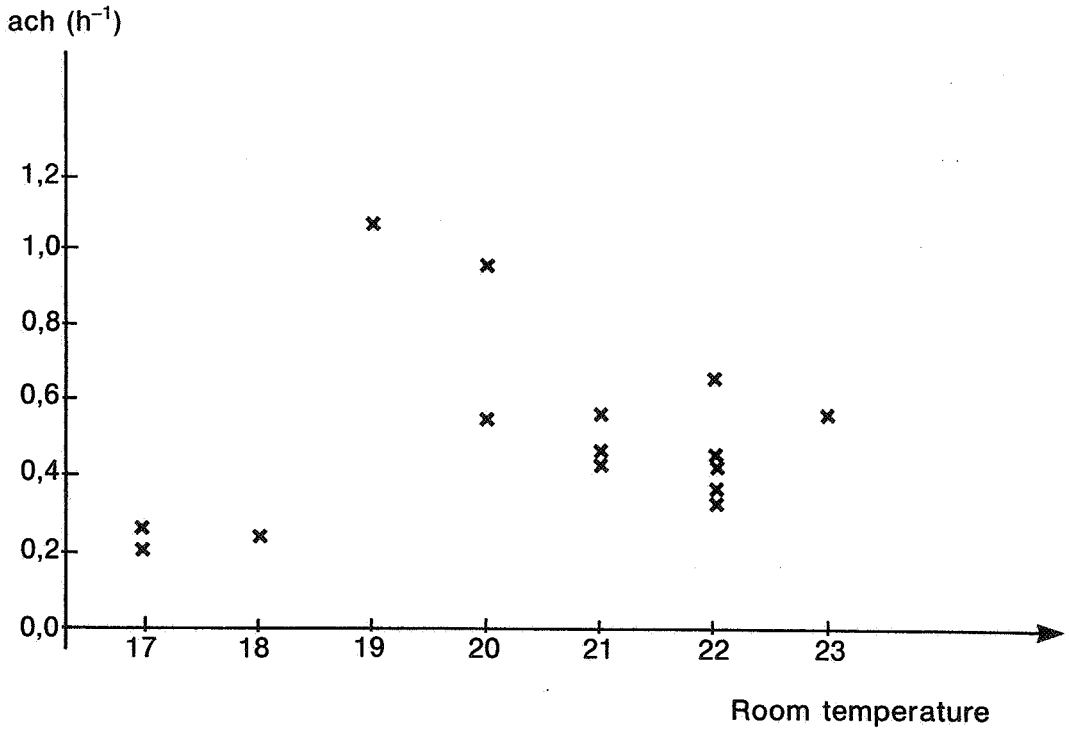

Fig. 7 Average total air change as a function of the room temperature for the 16 naturally ventilated dwellings.

From figures 4 to 7 it can be seen that the measurement results do not support any of the four assumptions about conditions that influence the ventilation habits of the occupants.

It is worth noticing, however, that the group in figure 7 is split into 2, a "comfort" group with an average to large air change or average to high room temperature, and an "energy-saving" group with low air change and low room temperature. All three members of the "energy-saving" group experienced considerable problems with heavy condensation of water vapour on the inside of the double-glazed windows.

Where Does the Air Enter?

Not all rooms receive the same amount of outdoor air. In 2-storey dwellings, the outdoor air will normally enter the dwelling by the lowest floor and then leave again from the uppermost floor.

In the 16 naturally ventilated dwellings, which have an average air change rate of 0.51 times/h, the average outdoor air change rate for the bedroom is 0.66 times/h and the average outdoor air change rate for the living room 0.36 times/h.

Conclusion

Measurement of air change rates in occupied dwellings shows that the occupants' behaviour has a very considerable influence on the total air change rate.

In the 16 naturally ventilated dwellings the users on average provide 63% of the total air change, but also in the mechanically ventilated dwellings, the user influence is considerable.

There is a very large difference in the air change rate from dwelling to dwelling. A difference which cannot be explained by differences in the tightness of the dwellings or the number of occupants. With the limited number and widely differing types of dwellings, which have been investigated here, it has not been possible to explain the large variations in the total air change.

The average total air change rate for the dwellings measured is 0.66 times per hour. Even though this rate is higher than the 0.5 times per hour recommended in Denmark, 20% of the dwellings measured had a total air change rate which was so low that indoor climate problems could easily arise.

Generally speaking, the occupants do not have sufficient possibility of regulating the air change in Danish dwellings. The only choice an occupant has is often either to open a door or a window or not to air the dwelling at all. Smaller ventilation openings which can be opened at varying levels and which are placed so that they can use the stack effect are seldom. Also in the mechanically ventilated dwellings, the regulation possibilities are limited, as the ventilation system, even set at the lowest level, normally gives a larger air change than required.

The measuring method used has proved to be most suitable for continuous measurement of the greatly varying air changes found in occupied dwellings.

References

B. Kvisgaard, P.F. Collet and J. Kure: Research on fresh air change rate: 1. Technological Institute, Copenhagen 1985.