THE USERS' INFLUENCE ON THE AIR-INFILTRATION

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INTRODUCTION

When calculating energy consumption for space heating and the concentration of pollution in the room air, knowledge of the dwelling's air-change rate is a prerequisite. The air-change rate to be applied in these calculations is the rate for the dwelling during normal occupancy.

Not until 1981, when the first complete sets of air-change measurement equipment capable of continuous registration had been fully developed, was it possible to measure air-change in dwellings during occupancy.

The paper presents the measuring technology, and the results from 23 one-week measurements of air-change in occupied dwellings.

The major part of the paper deals with the occupants' influence on the air-change in dwellings with and without mechanical ventilation systems.

Measuring equipment and measuring technology will be described briefly.

MEASURING EQUIPMENT

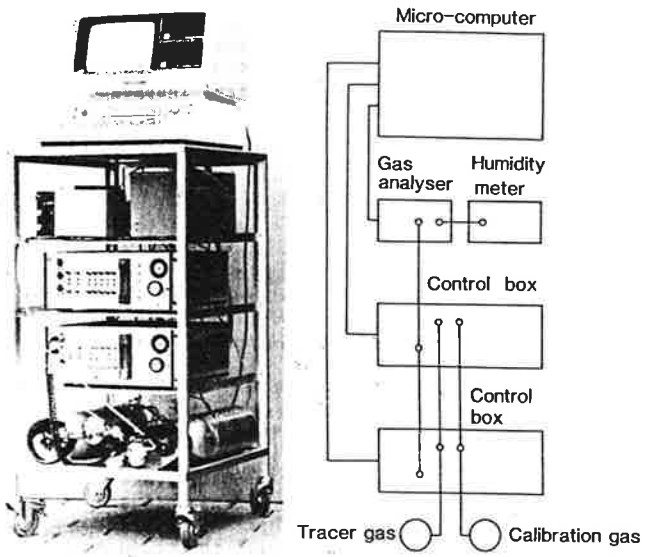
The measuring equipment has been designed to be capable of automatic registration of air-changes in occupied houses. The measuring principle applied is the method with "constant concentration of tracer gas".

The principle applied when measuring with "constant concentration of tracer gas" is that a constant concentration of a tracer gas is maintained in the rooms where the air-change is to be measured. The air-changes are then calculated on the basis of the quantity of tracer gas that it is necessary to dose to the rooms to maintain the concentration. We use the tracer gas SF_6 and the concentration in the rooms is maintained at 5 PPM.

The "constant concentrations of tracer gas" measuring principle has been selected because it is the only method which can be employed for continuous measurement in several rooms, where the air moves between the rooms.

The system is controlled by a micro-computer and constructed so as to be capable of measuring the air-change and humidity in up to 10 separate rooms. The measurement data are continuously gathered and stored on a diskette which can store 8 days' measurements.

Fig. 1. Unit's construction - photo, diagram



Each control box has two functions: to collect air samples from the rooms to the gas analyser, and to regulate the dosage of tracer gas to the rooms. The calibration gas is used for a periodic control of the gas analyser.

RESULTS

In the paper the air-change in the occupied dwelling is designated "total air-change", while the air-change registered in the sealed dwelling (i.e. with air-escape valve, doors, windows and ventilation system closed) is designated "basic airchange".

If the 23 measurements are classified according to the dwelling's ventilation system, it is seen that 14 of the measurements were in dwellings with natural ventilation, 6 in dwellings with mechanical injection and exhaust units and 3 measurements in dwellings with mechanical exhaust units only. The average size of dwelling was 106 m^2, while the average number of occupants was 2.7 - roughly corresponding to the national average for Denmark.

The average total air-change rate for the 23 dwellings is 0.68 times per hour, corresponding to 142 m^3 per dwelling per hour.

The difference in total air-change from dwelling to dwelling is shown in Fig. 2. Fig. 3. shows the distribution of the hourly resistrations of the total air-change in the individual dwellings. A typical example of the variations in the air-change of a dwelling is shown in Fig. 4.

Fig. 2. Distribution of the 23 dwellings' total air-change.

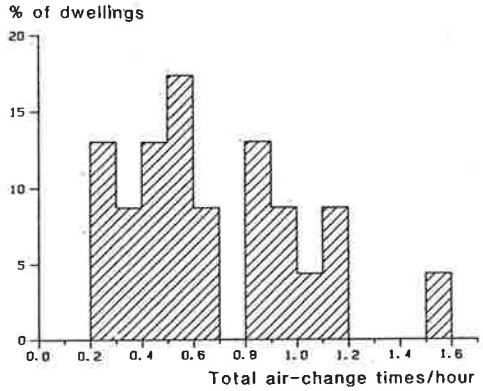


Fig. 3. Relative part of hourly registrations of the total air-change which are less than the x-axis value. The curves for all 23 dwellings are shown.

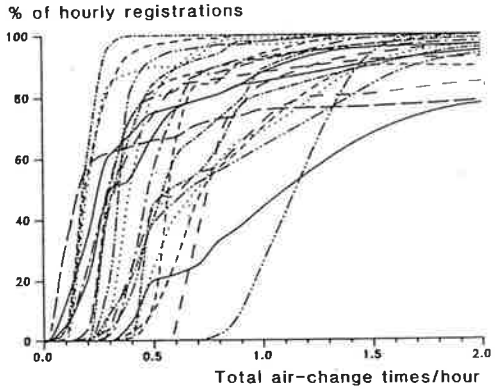
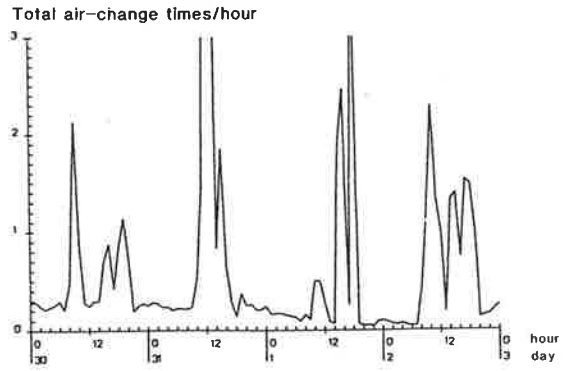


Fig. 4. Total air-change in a naturally ventilated dwelling. The air-change is shown as a function of time.



From Fig. 3 it can be seen that the distribution of the air-change varies greatly from dwelling to dwelling. They include both the steep S-curves which represent a fairly constant air-change over the measuring period, and the flatter curves which represent greater variations over the measuring period. Some curves are initially steep, and then snap and become flatter. These curves usually indicate periodic thorough airing.

Fig. 5 provides a clearer impression of the difference between naturally ventilated dwellings and mechanically ventilated dwellings.

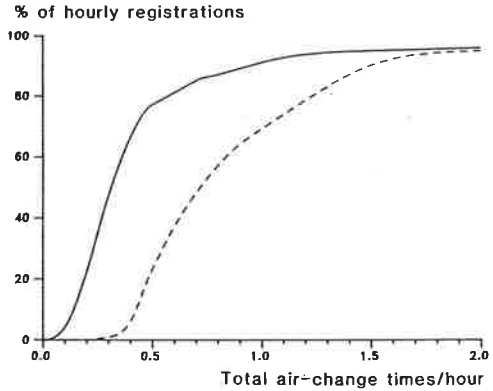


Fig. 5. Relative part of hourly registrations of the total air-change which are less than the x-axis value. The continous (line) curve is the average for the naturally ventilated dwellings, while the dotted curve represents the average for the mechanically ventilated dwellings.

Correlation between total air-change and basic air-change

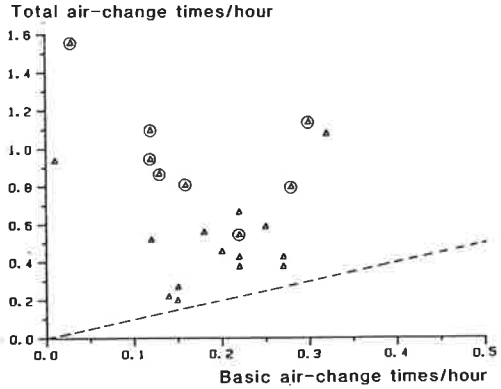


Fig. 6. Total air-change as a function of basic air-change for 22 dwellings. Mechanically ventilated dwellings are marked Ⓐ .

Fig. 6 demonstrates that there is no correlation between a dwelling's basic and total air-change.

As regards the mechanically ventilated dwellings, it is interesting to relate the total air-change to the dimensioned performance of the ventilation unit. Calculated on the basis of 6 dwellings the relationship was:

$$\frac{\text{total air-change}}{\text{performance ventilation unit}} = \frac{0.98}{0.58} = 1.7$$

As the occupants' behaviour exerts a very considerable influence on the air-change, it could be expected that the total air-change depended on the number of occupants.

This is, however, not the case, and the spread of the total air-change expressed in m^3 per occupant per hour is even bigger than the spread of the total air-change expressed in times per hour.

CONCLUSION

Measurement of air-change rate in occupied dwellings shows that the occupants' behaviour has a very considerable influence on the total air-change rate. On average, the air-change rate in an occupied dwelling is 3-4 times higher than the basic air-change rate.

The average total air-change rate for the dwellings measured is 0.68 times per hour. Even though this rate is higher than the 0.5 times per hour recommended in Denmark, nevertheless 20% of the dwellings measured had a total air-change rate so low that indoor climate probblems can easily arise.

The average total air-change rate for the dwellings measured varies from 0.20 to 1.56 times per hour.

Improved control of the total air-changes would achieve both energy savings and better indoor climate for the home.

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 systems usually give too high a rate of air-change, while the natural ventilation systems usually provide too low a rate.

The occupants' behaviour also exerts a considerable influence in dwellings with mechanical ventilation. The total air-change rate in the mechanically ventilated dwellings is, on average, some 70% higher than the rate which the ventilation system was designed to provide.

As no correlation has been determined between the dwelling's basic air-change rate and its total air-change rate, it is relevant to warn against drawing any conclusions with regard to a dwelling's indoor climate and its humidity balance on the basis of a single set of measurements of its basic air-change rate.

REFERENCE

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

SUMMARY

B.Kvisgaard: The users influence on the air-infiltration. Knowledge of air-change in dwellings under conditions of use is a prerequisite for calculation of energy consumption for space heating and for evaluation of a dwelling's indoor climate. This paper deals with the first series of measurements of air-change in occupied dwellings. Not until 1981, when the first complete sets of air-change measurement equipment capable of continuous registration had been fully developed, was it possible to measure air-change in dwellings during occupancy. The measurements conducted show that the occupants exert a very considerable influence on the total air-change. The air-change for occupied dwellings is, on aveage, 3-4 times greater than air-change in sealed dwellings (i.e. with air-escape valves, doors, windows and ventilation system closed). The measurements also reveal a trend indicating a higher rate of air-change in mechanically ventilated dwellings than in naturally ventilated dwellings.

RESUME

B.Kvisgaard: Influence du consommateur sur le renouvellement de l'air. Une connaissance du renouvellement de l'air vicié dans l'habitat est indispensable pour évaluer la consommation énergitique pour son chauffage et pour son climat intérieur. Dans cet article, il s'agit des premières séries de mesurage du renouvellement de l'air des surfaces habitables. Il est possible d'établir le mesurage dans les surfaces d'habitation que depuis 1981, date à laquelle les premières séries complètes de mesurage permettant l'enregistrement continu du renouvellement de l'air ont été mises au point. Les mesures enregistrées prouvent que les occupants ont une très grande influence sur le renouvellement de l'air dans les habitations utilisées, environ 3 à 4 fois supérieur à celui des habitations closes (bouches d'aération, portes, fenêtres et disposifs de ventilation fermés). Les mesures prouvent aussi qu'il y a une réelle tendence à ce que les habitations équipées d'appareils mécaniques de ventilation aient un renouvellement d'air supérieur à celui des habitations qui ne possèdent que des bouches d'aération naturelles.

KURZFASSUNG

B.Kvisgaard: Einfluss der Bewohner auf den Luftaustausch. Zur Berechnung des Energiebedarfs für die Raumheizung sowie zur Begutachtung des Innenklimas, ist eine Kenntnis über den Luftaustausch in Wohnräumen eine Voraussetzung. Dieser Artikel behandelt die ersten Messungen des Luftaustauschs in bewohnten Wohnräumen. Die Messungen des Luftaustauschs in Wohnräumen im Gebrauchszustand wurden erst nach 1981 möglich, als der erste Apparat zur laufenden Registrierung fertigentwickelt war. Die durchgeführten Messungen zeigen dass die Bewohner einen sehr grossen Einfluss auf den Luftwechsel haben. Im Durchschnitt ist der Luftaustausch in bewohnten Räumen 3-4 mal grösser, als in unbewohnten (Entlüftungsventile, Türen, Fenster und Ventilationsanlage geschlossen). Die Ergebnisse zeigen gleichfalls, eine Tendens in Richtung auf einen grösseren Luftaustausch bei mechanisch ventilierten Wohnräumen gegenüber natürlich ventilierten.