EFFECTIVE VENTILATION

9th AIVC Conference, Gent, Belgium
12-15 September, 1988

Poster 16

EXAMINATIONS ABOUT THE AIR HUMIDITY IN LIVED DWELLINGS DEPENDING ON DIFFERENT AIR VENTILATION SYSTEMS USING A NEW CHARACTERISTIC VALUE

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1. SUMMARY

This work deals with problems of the air humidity in inhabited dwellings. A new approach is presented here which renders the definite diagnosis of humidity problems possible.

The room air humidity from two buildings with different air ventilation systems with eight dwellings each is examined. The efficiency of the different ventilation systems is presented applying the new value, the so called "standardized room air humidity".

The results can be summarized as follows:

1.) The mechanical permanently balanced ventilation has essential advantages over the natural exhaust air ventilation in buildings.

2.) Dwellings with permanently balanced ventilation show distinct advantages concerning air humidity. The values of absolute air humidity are lower in these dwellings than in dwellings with natural exhaust air.

3.) By applying the "standardized room air humidity" the problem of humidity can be shown quantitatively. It could be proved that the standardized value expresses the real situation.

4.) In dwellings with permanently balanced ventilation there is no danger of humidity problems. The average natural exhaust air in dwellings reaches dangerous limits, some of them exceed the limit considerably.

5.) A definite correlation between outdoor temperature and the standardized room air humidity has been proved.

2. INTRODUCTION

Humdity problems have more often occurred during the last years. Mostly mould grove is the consequence, which does not only look dirty but also smells foul. In most of the cases mould grove and its spurs cause diseases such as of allergies. Apart from the inhabitants, who are worried about hygienie and their health, the building sponsors and architects are more and more interested in avoiding humidity damages. Mould grove reduces the quality of living. The causes for humidity damages are numeroes and influence themselves contrarily. Often the reason cannot be fully confirmed. Therefore many cases have to be settled in court.

In the past few years this topic has often been discussed in the media. The reasons are: Allergies are frequent, houses become tighter and tighter and the awareness for environmental problems is increasing.

3. INTRODUCTORY REMARKS ABOUT INDOOR AIR HUMIDITY

First it has to be mentioned that humidity damages being caused by long-lasting condensation processes on surfaces are described in this report. Apart from condensation there are many damages caused by leaks. In most of the cases these can be repaired easily. The condensation humidity causes damages which are long lasting and which can hardly be repaired.

First it will be shown which factors influence the condensation on the wall surface. One has to differentiate between structural statics and constructive influential factors and the user behaviour.

In Germany the building cover has to be build in accordance with many rules. For example, DIN 4108 /1/ prescribes the insulation of a building. By this it is made sure that the inner wall surface temperature does not lead to condensation under normal circumstances. However this is actually much more difficult because there are heat bridges, constructive errors and other characteristics of the respective building. Critical surface temperatures are seldom found on the plane wall, but mostly in corners (geometrically caused higher k-value) and on window surfaces (higher k-value as compared with a plane wall).

The user also exerts a certain influence on the humdity condensation. The daily life in a dwelling causes a lot of humidity: Washing, cooking, cleaning, man himself, animals and plants are humidity producers. In a dwelling humidity would increase continually if natural ventilation did not diminish it. A much smaller amount is absorbed in the upper wall surface.

In the past dwellings have often been so untight that natural ventilation carried away all humidity. The exchange of the old untight windows for new energy saving ones with double sealing makes these dwellings absolutely airtight. A sufficient ventilation of these dwellings is only possible by opening the windows. This way of ventilation, however, is "uncontrolled" and wastes energy.

Thus it is reasonable to install ventilation systems in modern buildings. These systems guarantee "controlled" exhaust and supply of air. Furthermore it is possible to regenerate the high energy of the exhaust air and to add it to the fresh air again.

4. THE RESEARCH PROJECT

The results presented here were gained during a research project /4/, in which dwellings with different ventilation systems were compared. All dwellings had the same groundfloor plan and were inhabited except for one research dwelling. The research dwelling was not inhabited and served as reference.

Some dwellings are ventilated and exhausted mechanically, some are ventilated conventionally. Figure 1 shows the groundfloor plan of each dwelling.

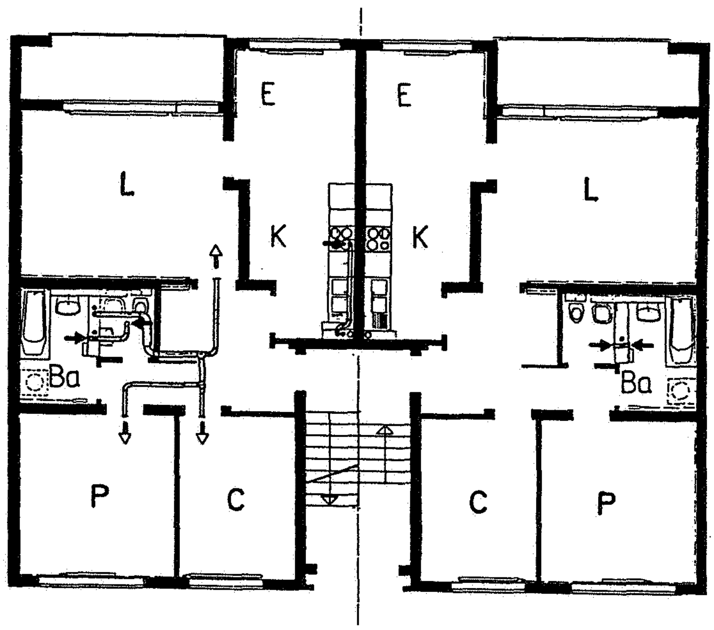

Fig. 1: Groundfloor plan. On the left hand: mechanical ventilation system. On the right hand: balanced ventilation

In Germany rule DIN 18017 /2/ requires that inner rooms without windows have to be ventilated. In rented flats mostly a simple shaft ventilation is installed, the so-called "Kölner Lüftung" /2/. Some of the dwellings of the research project are equipped with this system (here called conventional or natural ventilation).

The other dwellings have a mechanical system of ventilation. The air is exhausted in the inner rooms, toilet, bathroom and kitchen, there humidity and smell are very prominent. The fresh air is warmed up and led to the livingroom, children's room and bedroom. The hall serves as the zone of overflowing.

Fresh and exhausted air are led separately. The central unit is equipped with a recuperative heat exchanger where the energy of the exhaust air warms up the fresh air. Both streams of air are not mixed. The fresh air is entirely outdoor air. This system can be made more efficient by using an heat pump, but this will not be discussed here.

Temperature and air humidity are continually measured and registrated in all rooms, in the exhaust and fresh air as well as in weather station outside the building. Based on the number of dwellings, one can say that the statements made are realistic.

5. THE STANDARDIZED ROOM AIR HUMIDITY - A NEW VALUE

The measured results of these dwellings at first did not allow definite statements. Therefore the author introduced a new value - the so-called standardized room air humidity. The until today mainly used value - the relative air humidity - only describes the air condition based on a certain temperature at a certain place. The relative air humidity is a generally used value, but it cannot be applied when comparing diffe-rent flats.

The absolute air humidity directly shows the amount of humidity in a room, but it does not include the dew-point. The standardized air humidity X avoids these disadvantages and makes it possible to show the in-fluence of outdoor humidity.

The value is defined as follwos:

$$X = \frac{x_i - x_a}{x_{Sio} - x_a}$$

x_i absolute indoor air humidity
x_a absolute outdoor air humidity
x_{Sio} absolute saturation of dew humidity on an inner surface

6. RESULTS OF THE STUDY

With the help of the presented definition the standar-dized room air humidity can be calculated, if the unfa-vourable wall surface is known. For the following exa-minations the window surface was chosen for calculating the dewpoint humidity because the k-value of the win-dows have a lower value as the walls of the research building. The results are gained for each dwelling and presented in the following graphs as day mean values. Two different forms of presentation are chosen. The first form shows the results chronologically during the year. In a second form the values are presented according to the outdoor temperature.

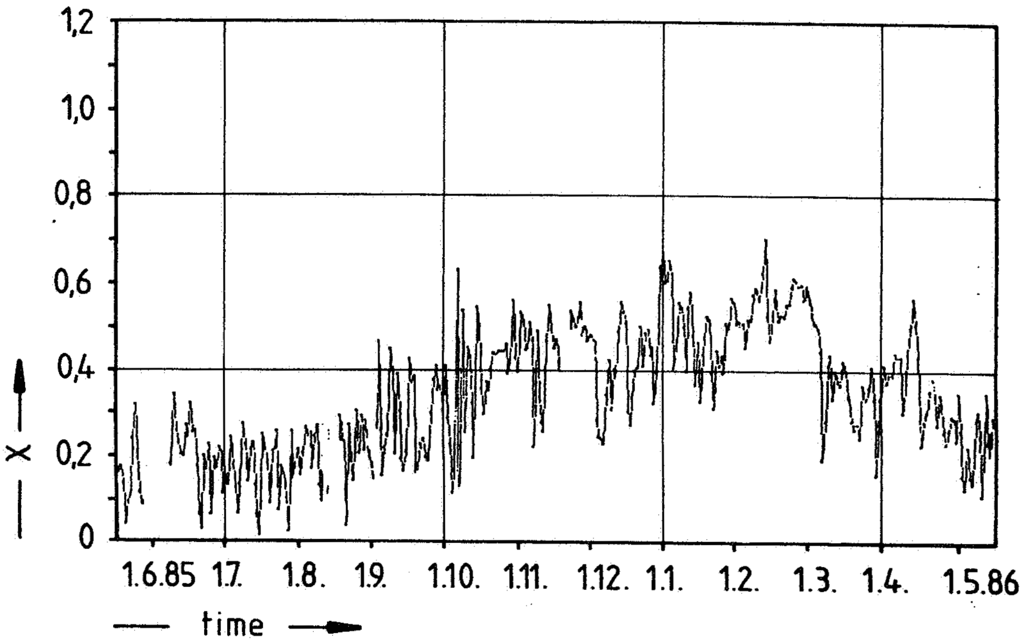

Fig. 2: The standardized air humidity during the year

Figure 2 shows the typical course of the standardized air humidity of an inhabited dwelling with mechanical ventilation during the year. By this figure the possible values of the standardized air humidity are shown. X-values between 0.5 and 0.8 suggest normal use of the flat. X-values higher than 1 imply that the dewpoint on this surface is exceeded. Values lower than 0.5 indicate that humidity is hardly produced, or, that efficient ventilation has exhausted the produced humdity.

Figure 3 presents the comparison of the different dwellings and ventilation systems. The values are plotted over the outdoor temperature. The results can be marked by straight lines being highly accurate (see /3/).

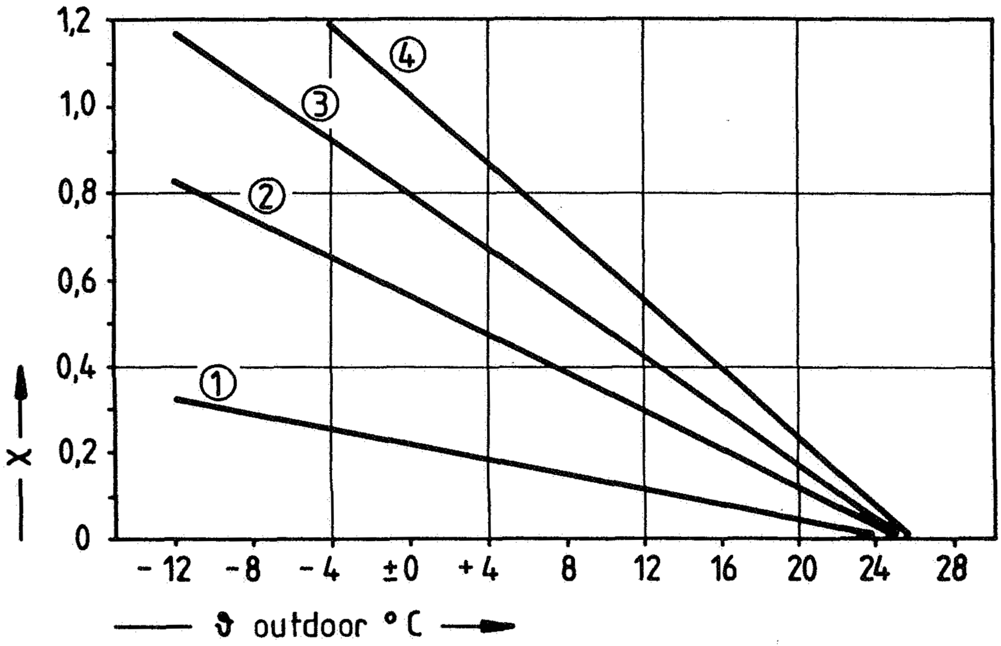

Fig. 3: The standardized room air humidity depending on the outdoor temperature with different ventilation systems (Presentation by equalized straight lines)

1 uninhabited research dwelling
2 mean value of 6 mechanically ventilated dwellings
3 mean value of 8 naturally ventilated dwellings
4 maximum value of a naturally ventilated dwellings

7. CONCLUSIONS

The following statements can be deduced from figure 3:

1.) In all graphs (including the ones not given here) a linear relationship between the standardized air humidity X and the outdoor temperature can be detected.

2.) There is no tendency to greater humidity problems during the transitional period. This would become obvious by bending the straight lines at outdoor temperatures of 4 to 12 °C.

3.) The source of all straight lines, i.e. the value X = 0 and thus $x_i = x_a$, lies at τ = 25 °C. This effect is independent from different ventilation systems and an indication for window ventilation in summertime. My own observations during high outdoor temperatures confirm this theory. The opening of windows increases the air change ratio considerably, by this inner and outdoor air humidity are balanced immediately.

4.) The maximum values of the standardized air humidity are reached during low outdoor temperatures. Primarily they depend on the different ventilation systems, than on the behaviour of the user. In dwellings with mechanical ventilation systems there are no humidity problems to be expected. In all natural ventilated dwellings, however, critical values are reached during lower temperatures. A few dwellings have X-values over 1 which means that humidity problems are to be expected. When visiting these dwellings, humidity damages have been found.

8. LITERATUR

/1/ DIN 4108 (1981): Wärmeschutz im Hochbau (Teil 1 - 4)

/2/ DIN 18017: Lüftung von Bädern und Spülaborten ohne Außenfenster, Blatt 1 - 4

/3/ Schmickler, F.-P.: Untersuchungen über die Luftfeuchte von Wohnungen in Abhängigkeit von unter schiedlichen Lüftungssystemen unter Verwendung einer neuen Kennzahl, Dissertation Universität Dortmund, 1987

/4/ Trümper, H.; Hain K.; Schmickler, F.-P.; et.al.: Verschiedene Forschungsberichte, Demonstrationsvor haben Duisburg, BMFT Bonn (Hrsg.)