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The h,x-diagram as a Representation of Measurements of Ranges of Comfort in a Long-Duration Test

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Abstract

It is well known that the inhabitants of dwellings use the room heating and ventilation to build up their own individual climatic zone in which they feel comfortable. To date individual measurements have been conducted to investigate these climatic zones, or line charts have been drawn up with a thermohygrograph in long-duration tests.

Compared with the form of presentation used previously, the possibilities for evaluation have been substantially improved by the use of measured data-recording installations for the long-term investigation and presentation of results in the form of dots (temperature/humidity value pairs) in an h,x-diagram. The h,x-diagram is a type of psychrometric chart which is widely used in Germany. The advantage of this chart is that all thermodynamic properties of moist air can be determined without calculation. The dry bulb temperature, the wet bulb temperature, the dew point, the relative humidity, the humidity ratio, the specific enthalpy and the specific volume of moist air can be read directly from the diagram.

KEY WORDS:
Dwellings, Ventilation, Moisture, Long-term measurements, h,x-diagram.

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Introduction

Problems always arise with living room humidity levels when the humidity in occupied rooms exceeds the range of the sultry limit and there is the risk of structural damage and health hazards.

Nowadays, when many dwellings are designed with tightly fitting windows and other structural measures in such a way that they require the minimum of heating energy, low air exchange rates lead to high room humidities.

In winter in particular, it is difficult, with regard to energy conservation, to supply outside air to dwellings in such a way that the amount of energy needed to heat the air is as small as possible. On the other hand, it is precisely during the winter months that a continuous volumetric flow from outside into the dwelling has a tendency to dry the internal air. An attempt has to be made to find a compromise between both possibilities: dwellings which are not tightly insulated have a high energy consumption and low humidities, whereas very tight dwellings display a low air exchange and hence higher room humidities.

With this in mind, test structures have been built over a period of time which were intended to establish the links between temperature, humidity, energy and ventilation systems in occupied dwellings (Jansen, 1989; Trümper et al., 1989). In the tests conducted, special attention should be paid to the ventilation systems, because they have a major effect on internal room humidities.

The Ventilation Systems

The test structures provide the source of the measured data and the h,x-diagrams, and they consist of two types of dwelling.

First, dwellings with a combination of natural supply air shaft in the hallway (Dortmund ventilation system) and exhaust air shafts in the kitchen and bathroom based on the Berlin ventilation system.

Second, dwellings with only exhaust air shafts in the kitchen and bathroom (Berlin ventilation system). In this case, the supply air has to flow in through the window joints. With windows of more modern design, where extreme joint tightness is required, the natural inflow of outside air is insufficient for the requisite minimum air exchange. Therefore, additional window ventilation is needed, but this is not provided in the cold season because of old habits (old buildings had adequate air exchange without window ventilation because of the lack of tightness in the window joints) and because of the wish to conserve heating energy.

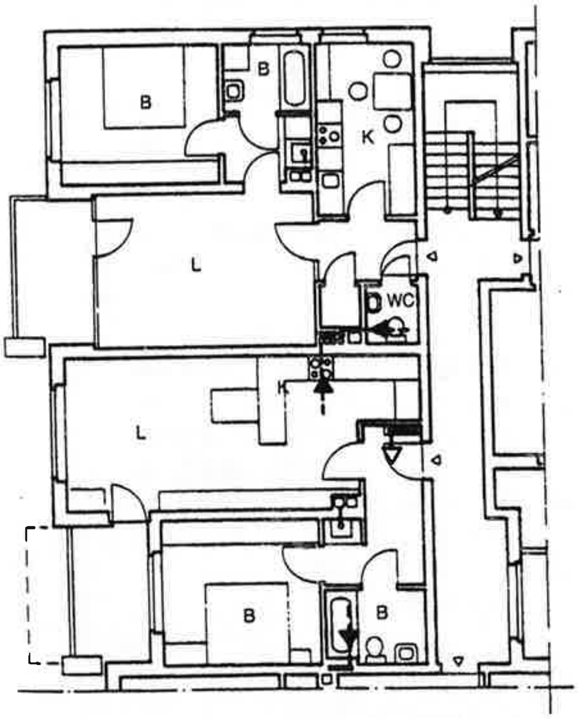


Fig. 1 Layout of the test dwelling and the neighbouring corner dwelling showing the arrangement of shafts.

Figure 1 shows the layout of a test dwelling and the neighbouring corner dwelling. The only interior room in the corner dwelling is the WC. The ventilation system for the WC is the "Berlin" system, which is widespread in rented housing. The exhaust air is extracted through a shaft in the WC. Since the kitchen, which has an outside wall, and the bathroom in this dwelling each have a window for ventilation, there is no exhaust air shaft. Under the State Construction Code, additional ventilation facilities are not mandatory for kitchens and bathrooms with exterior walls. This means that the kitchen and bathroom have to be ventilated, as required, through the window. Only for the interior WC is there a flow of supply air through the leaks in the building shell.

In the test dwelling one can see the exhaust air shafts of the "Berlin" ventilation system in the bathroom and the kitchen. Furthermore, there is in the hall, right next to the front door, the supply air shaft of the "Dortmund" ventilation system for the natural inflow of outside air. During the tests, there is the possibility of closing the opening between the supply air shaft and the hall.

Figure 2 shows a cross section through the whole building. It shows the supply air shafts of the "Dortmund" ventilation system and the exhaust air shafts of the "Berlin" ventilation system. It highlights that the supply air can be introduced into the building as required at street level or through the roof.

For the purpose of comparison, there are three further dwellings in the house which have the same layout, and also an attic flat with a similar layout. These dwellings are also equipped with the natural supply air shaft of the "Dortmund" system and the exhaust air shafts of the "Berlin" ventilation system.

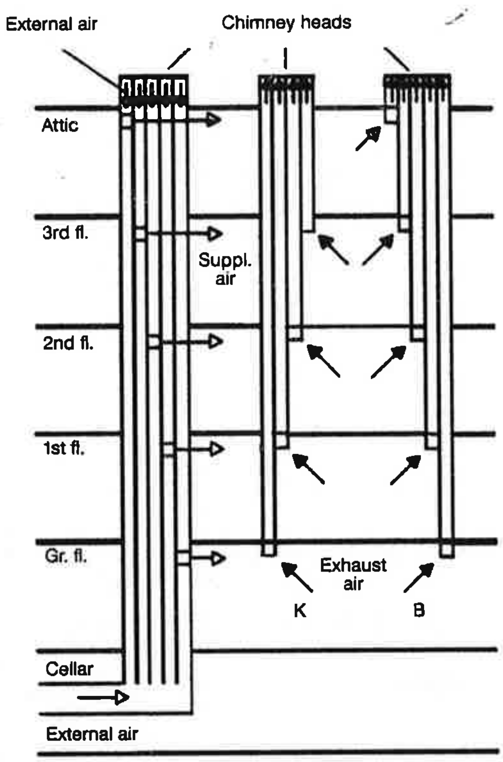


Fig. 2 Cross section through the building.

Method of the h,x-Diagram Applied

A new type of presentation of the measured values is obtained in conjunction with the h,x-diagram according to Mollier (Jansen, 1989).

For this purpose, the values for temperature and relative humidity as measured hourly over a specific period are plotted in the h,x-diagram. This leads to actually measured comfort fields, which are compared with the comfort field in DIN 1946 (DIN 1946, 1983), applicable for air-conditioned rooms, and with the comfort field in Leusden and Freymark (Leusden and Freymark, 1951; Schmickler, 1987).

If one compares the comfort fields presented by measurements as shown in Figure 3 with the fields mentioned above, they are at the right-hand margin of the comfort fields in the direction of high humidities. The following central points in the comfort field are obtained.

Summer:	Temp. 24 °C	at	11 g/kg	abs. humidity
Autumn:	Temp. 21 °C	at	10 g/kg	abs. humidity
Winter:	Temp. 20 °C	at	8 g/kg	abs. humidity
Spring:	Temp. 21 °C	at	7 g/kg	abs. humidity

If one were to define a new comfort field from the values measured, it would not run parallel to a constant temperature, in contrast to the aforementioned fields, but rather along a relative humidity curve. In this dwelling the comfort field runs almost along a relative humidity of approx. 60%.

The course along the relative humidities is made particularly clear by the results from the measurements taken in the winter months. It is clear that with fluctuating inside temperatures the relative humidity remains almost constant, while the absolute humidity changes with temperature. This means an increase in humidity with rising temperature and a fall in humidity with falling temperature. The reason can only be the

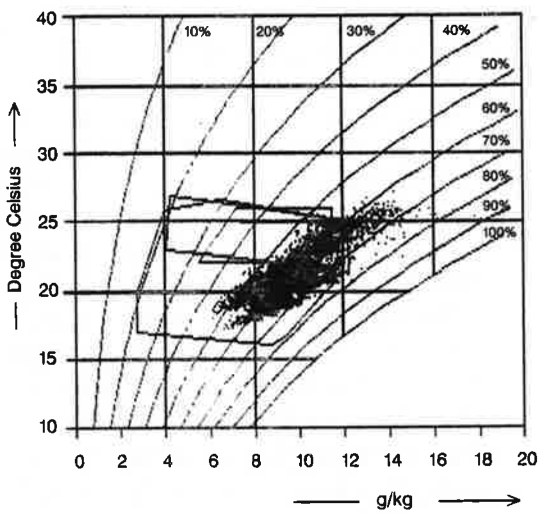


Fig. 3 Temperature and humidity throughout the year.

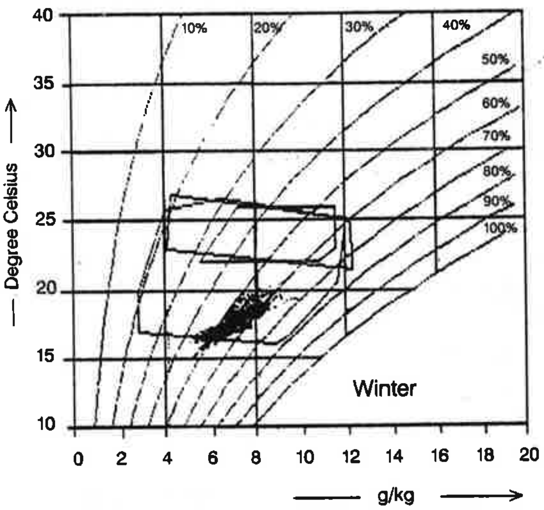


Fig. 4 Flat ventilated by "Dortmund Ventilation" in winter.

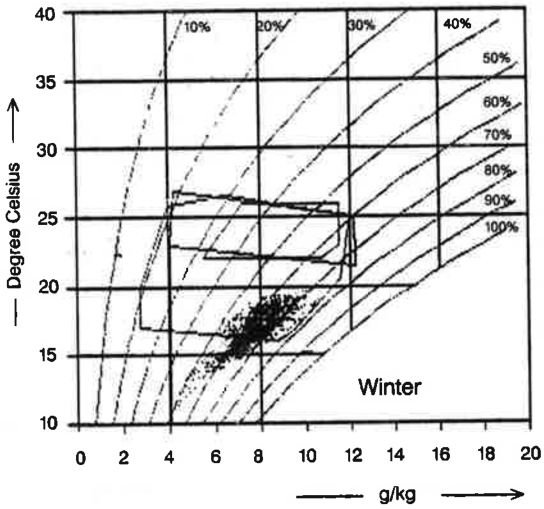
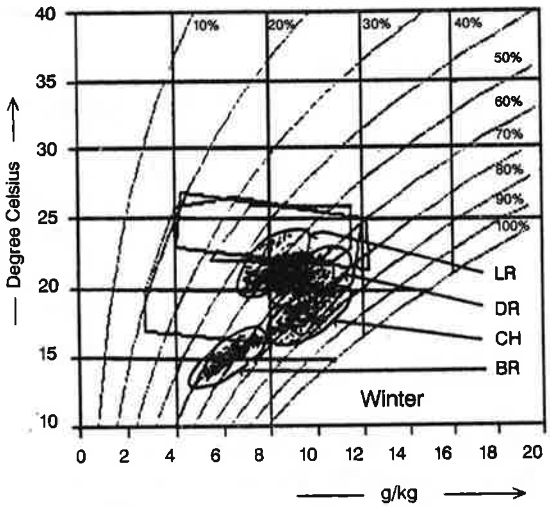
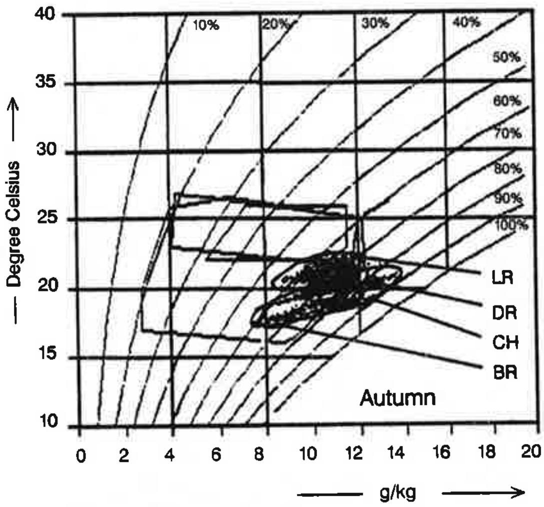


Fig. 5 Flat ventilated by "Berlin Ventilation" in winter.



LR = Living Room
DR = Dining Room
CH = Children's Room
BR = Bedroom

Fig. 6 Flat ventilated by "Berlin Ventilation" with only rarely opened windows in winter.



LR = Living Room
DR = Dining Room
CH = Children's Room
BR = Bedroom

Fig. 7 Flat ventilated by "Berlin Ventilation" with only rarely opened windows in autumn.

adsorption and desorption on the part of the masses such as ceiling and walls, especially plaster surfaces, items of furniture and carpets. The additional humidity arising in this dwelling from people, animals, plants and processes (in the kitchen and the bathroom) must invariably be extracted by an adequate ventilation system.

Figures 4 and 5 show the difference between a dwelling with supply and exhaust ventilation, together with a dwelling with only exhaust ventilation. The figures show that the dwelling with supply and exhaust ventilation (Dortmund ventilation) is drier than the one which has only exhaust ventilation (Berlin ventilation). These dwellings were also regularly ventilated by opening the windows, as demonstrated by a survey of the inhabitants. Figures 6 and 7 show the state of the room air in a dwelling with the "Berlin" ventilation exhaust air system with rarely opened windows. These figures are for a social dwelling built in the 1980s. With relative humidities of 70% to 90%, there is thus the risk of health hazards and building damage. According to an extensive survey conducted in social dwellings in Belgium (Wouters et al., 1988), encompassing 1115 single-family houses and 1219 flats, 30% of all rooms are not ventilated. This result underscores the need for a supply air system as provided by the "Dortmund" ventilation system.

The method of the applied h,x-diagram reflects the result of all influences on the room climate. In addition to the ventilation behaviour, the user behaviour (opening of windows, closing of doors, heating of the dwelling, use of the kitchen and bathroom etc.), as well as the outside climate, influence the room climate. Tests therefore have to be conducted to largely exclude the user behaviour and dwelling fittings, the aim being to confirm that a dwelling with "Dortmund" ventilation with exhaust air shafts is drier than one with only "Berlin" ventilation. The results of these tests are presented in Trümper and Albers, 1990.

The method of the applied h,x-diagram makes it possible to compare, very quickly and with little effort, dwellings beyond a single year. The result of all influences on the room climate is shown here. To obtain information on individual influencing factors which act on the room climate, it is necessary to conduct further tests.

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