

PROGRESS AND TRENDS IN AIR INFILTRATION  
AND VENTILATION RESEARCH

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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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## SUMMARY

A new visual method is yielded by a particular application of Mollier's h,x-diagram. Point fields (temperature and humidity) lead to a significant improvement upon previous graphic methods.

Flats with mechanical balanced ventilation are drier and more influenced by the exterior climate than are with shaft ventilation system ventilated flats ("Berlin ventilation").

The evaluation of the graphic representation of the experimental results in the form of curves permits rapid assessment of the experimental results.

When the experimental data is plotted in Mollier's h,x-diagram, the comparison with fields of comfort published in the literature becomes possible.

The display of the experimental data in Mollier's h,x-diagram further allows both differences between individual flats and seasonal behavioural changes of the occupants to be displayed in a small number of diagrams.

## 1. INTRODUCTION

Problems with moisture in dwellings always occur whenever the air humidity in inhabited rooms exceeds a certain value and causes damage to buildings or health.

At the present time, when much housing is planned with closely-fitting windows and other structural measures to minimize consumption of energy, low air-exchange coefficients (/7/, p.1193) often lead to moisture damage (/1/, /3/, /5/, /8-12/).

Particularly in winter, it is difficult from the energy-saving point of view to introduce outside air into a dwelling in such a manner that the minimum quantity of energy is needed to heat this air.

On the other hand, especially in winter, a continuous flow of outside air into the dwelling tends to dry the air inside.

The attempt must therefore be made to find a compromise: draughty dwellings have energy costs, whilst well-insulated and tight dwellings may have

such low air-exchange coefficients that the health of the inhabitants suffers.

Consideration of these aspects has led to the emergence of various test buildings which should make it possible to determine the relationships between temperature, humidity, energy and ventilation systems (/5/) in inhabited dwellings. In the investigations, particular attention is paid to the ventilation systems since these significantly influence the interior humidity (/8/, /11/).

## 2. THE VENTILATION SYSTEMS

The experimental building which yielded the experimental results and thus the h,x-diagrams was approved by the BMFT (Federal Ministry for Research and Technology) in Bonn as an experimental building, and was put into operation in 1983 in Duisburg, in order to investigate various ventilation systems (/10/).

Some of the flats were provided with mechanical balanced ventilation via air-ducts whereby the energy of the exhaust air is transferred to the supply air via a heat-exchanger. The supply air is led into the living area and the discharge air is exhausted from bathroom and kitchen.

The second research house is an equivalent block of flats in the same housing estate; this building has another ventilation system: conventional shaft ventilation which is also known as "Berlin ventilation". Here the air is coming through the window rabbet or the opened window.

Temperature and humidity were detected by four sensors (bedroom, children's-room, dining-room, living-room).

Initial results from the Duisburg experiment are listed in /9/.

Numerous measurements in the experimental flats yielded experimental curves with which visual comparison was used in an attempt to discover the positions at which condensation was favoured: these points were above all windows and outside walls. The surface temperature of these building elements is determined on the one hand by constructional factors (e.g. U-value (/7/, p.128)) and on the other hand by the interior air temperature which the occupants can regulate with the aid of the heating system. Further, initial conjectures on the influence of the

ventilation system were made: "The highest humidity values were measured in flats with tightly-fitting windows but without mechanical ventilation" (/9/, p.112).

### 3. METHOD OF THE APPLIED H,X-DIAGRAM

A new manner of representing the measured values is indicated by the h,x-diagrams of Mollier (/7/, p.100ff.).

The values of temperature and relative humidity measured hourly during one month are plotted in the h,x-diagram. This yields experimentally-measured comfort fields which are contrasted to the comfort fields according to DIN 1946 (/2/) and Leudsen-Freymark (/5/, p.130 ff.; /8/, p.14).

Comparison of the experimentally-measured comfort fields with e.g. DIN 1946 reveals agreement during the summer months only, whilst the experimental data is most nearly approached by the Leudsen-Freymark comfort field during the other months.

In comparison to both comfort fields, however, the measured values are concentrated towards the right-hand edge of the comfort limits (to higher relative humidity).

The following mean values define the comfort field:

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 a new comfort field is defined by the experimental values, this does not lie parallel to a constant temperature as is the case for the above-mentioned fields, but rather lies along a relative humidity of approx. 55 %.

The course at constant relative humidity is especially conspicuous for measurements made during the winter months. It becomes clear that the interior relative humidity remains approximately constant despite fluctuating interior temperatures, whilst the absolute humidity varies with the temperature.

This does not however mean that the flat becomes absolutely dryer when it is heated more, but that the water content of the air increases, and the relative humidity remains almost constant. A possible cause is absorption and desorption from walls and furniture.

The h,x-diagrams for the summer (Figs. 1.1 and 2.1) show that the values for all interior rooms are concentrated around a nucleus at about 25 °C and 50 % - 60 % relative humidity, similar to the exterior weather data. According to the number of occupants it is more humid or drier.

In autumn (Figs. 1.2 and 2.2), the temperatures are lower. The relative humidity increases significantly, and decreases somewhat as winter approaches.

In winter (Figs. 1.3 and 2.3), different comfort fields are found for different rooms, which will certainly be the result of attempts by the occupants to save energy by keeping the room doors closed as far as possible.

Towards spring (Figs. 1.4 and 2.4), the comfort fields are less dispersed. The bedrooms are still cold, whilst the first rays of the sun raise the living-room temperatures somewhat (south-facing living-rooms). Since heating continues to be required, the living-rooms remain warmer. The zone of comfort follows a constant relative humidity in this case too.

The high relative humidity - about 85 % - in autumn (Fig. 2.3) of flats with "Berlin ventilation" is of interest. Although walls and furniture store moisture, this property has only a short time-span of one or two days.

The main proportion must therefore arise from exterior humidity. As soon as the sun shines, the occupants open the windows, and exterior air streams into the flats. When the weather deteriorates, the windows are at once shut, and the moisture remains in the flat because the "Berlin ventilation" cannot transport so much exhaust air. Since the autumn weather is generally very changeable, and the flats are heated irregularly, the high humidity remains in the flat until winter when heating is continuous.

The method of applied h,x-diagrams permits a rapid and simple visual comparison of flats throughout the year, whereby the influence of the occupants' lifestyle too (e.g. the closing of doors) can clearly be recognized.

h,x-diagram: representation for flats with balanced ventilation

Fig. 1.1

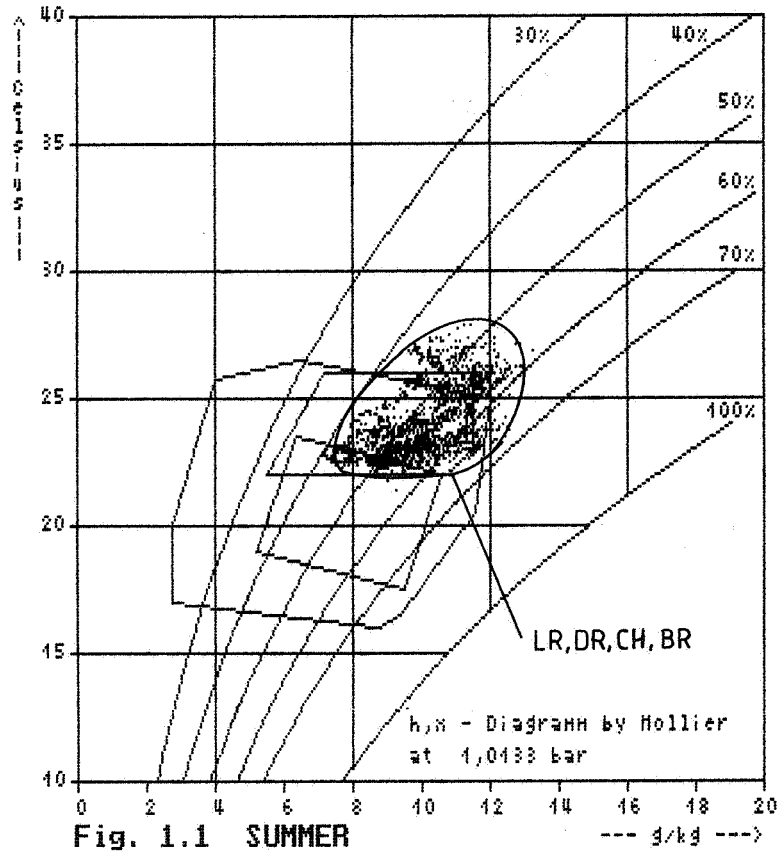
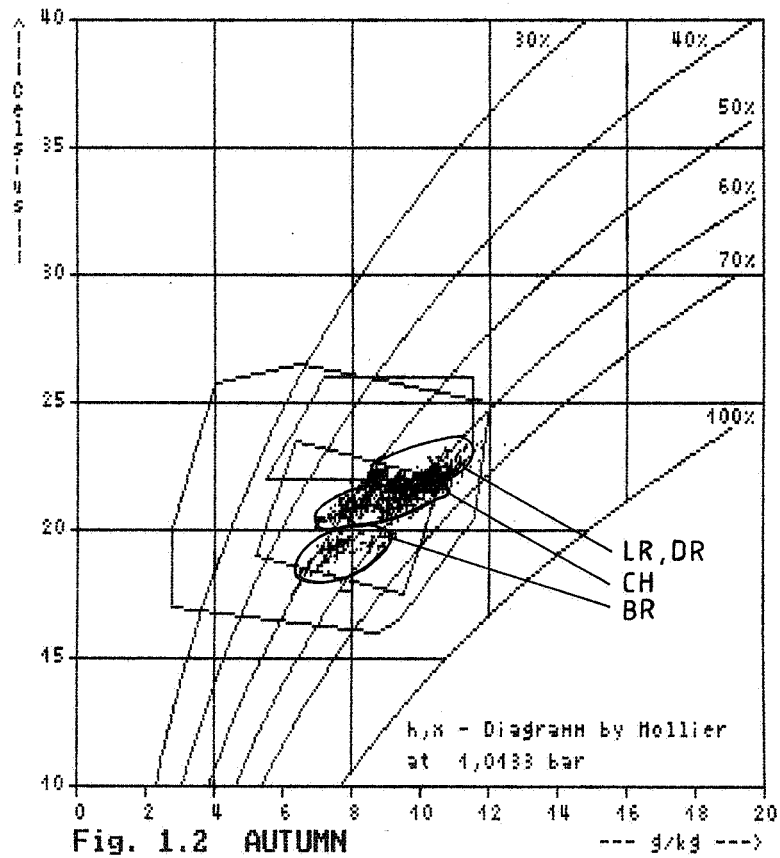


Fig. 1.2



h,x-diagram: representation for flats with balanced ventilation

Fig. 1.3

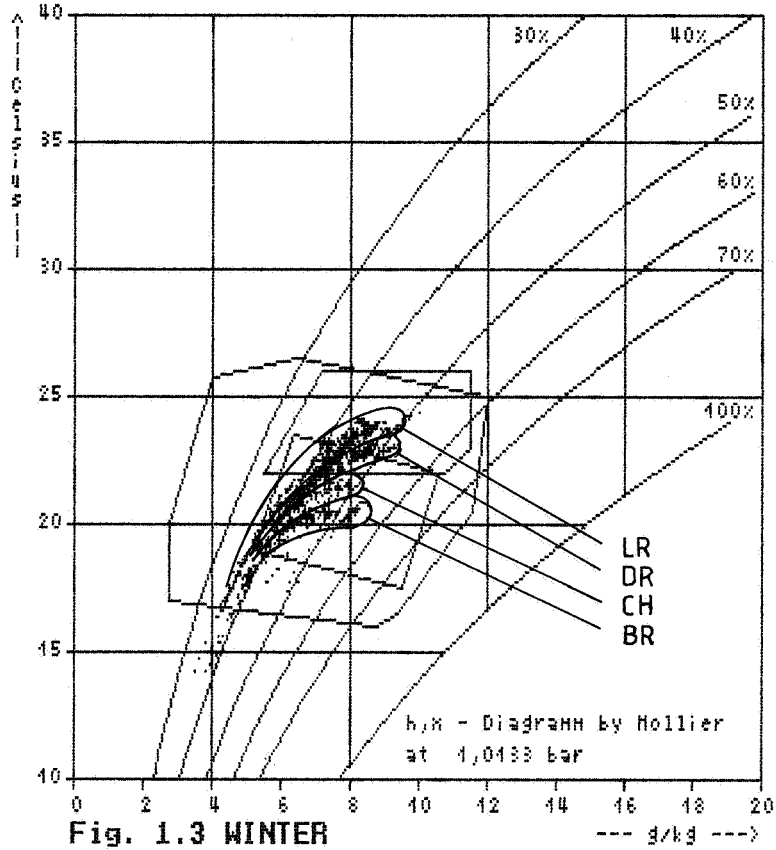
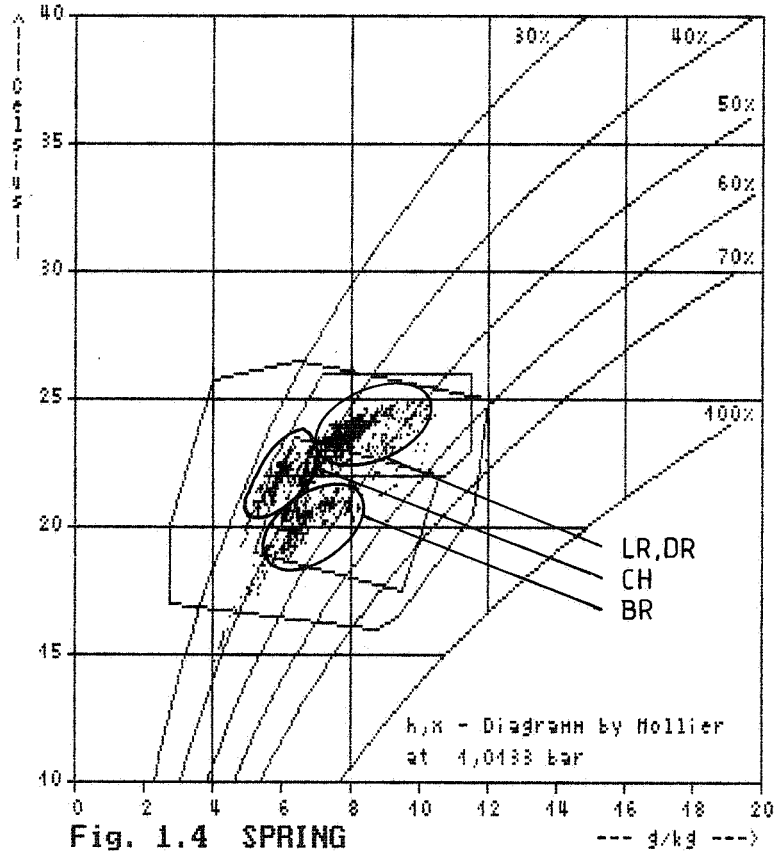


Fig. 1.4





h,x-diagram: representation for flats with Berlin ventilation

Fig. 2.1

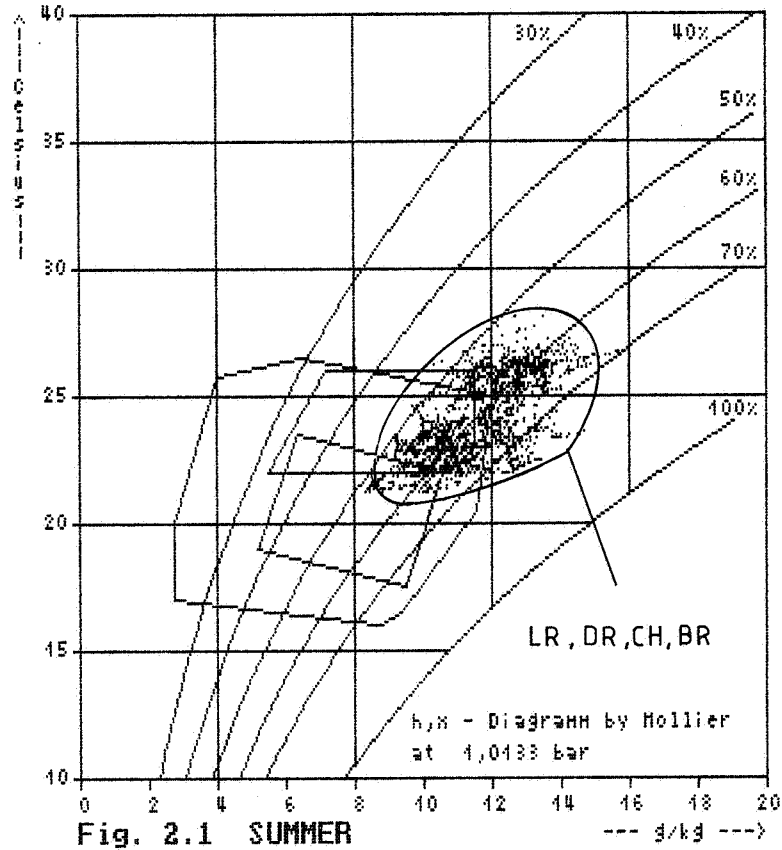
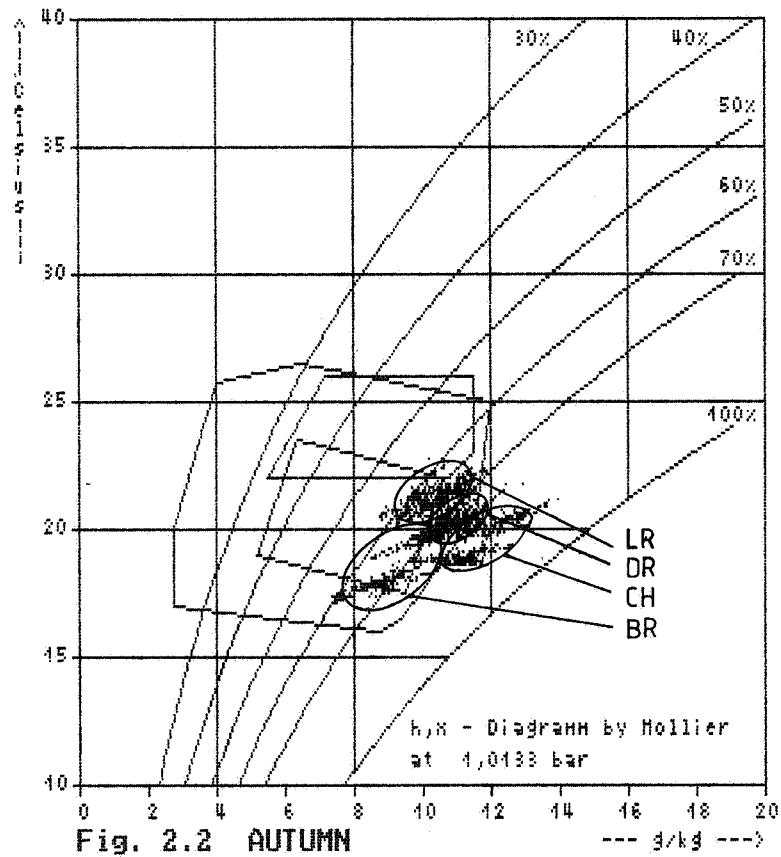


Fig. 2.2



h,x-diagram: representation for flats with Berlin ventilation

Fig. 2.3

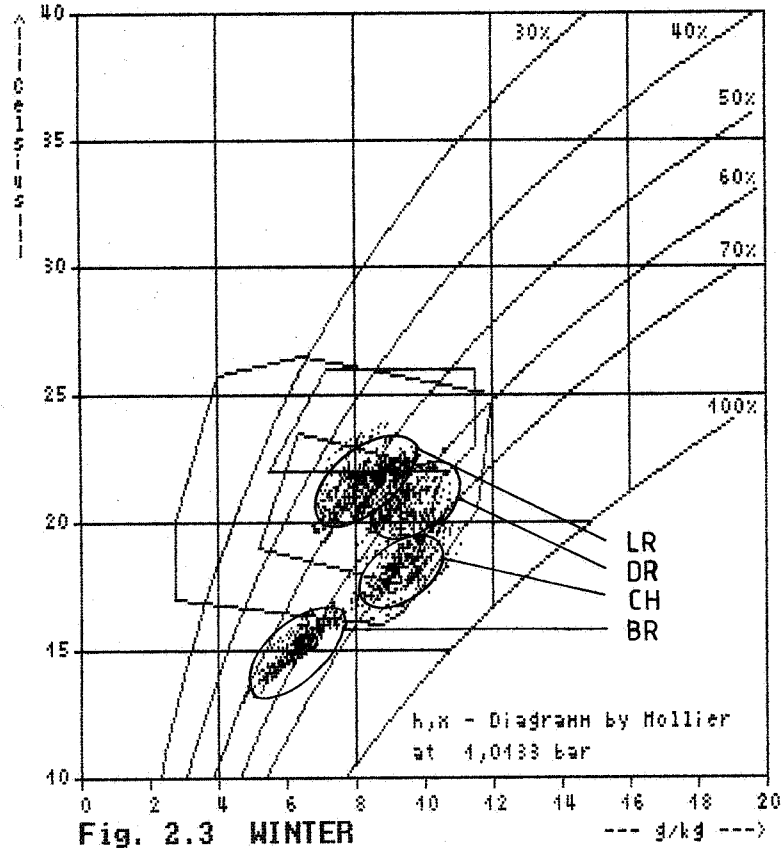
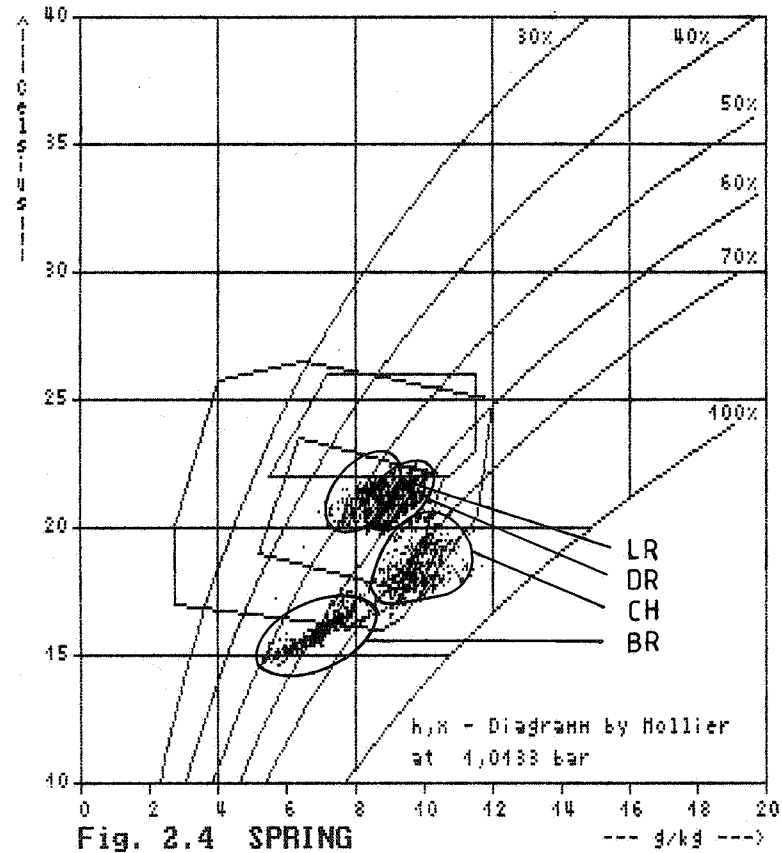


Fig. 2.4



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LIST OF SYMBOLS

Fig. - figure

°C - degree Celsius

g - gram

kg - kilogram

LR - living-room

DR - dining-room

CH - children's-room

BR - bedroom