CONTROLLING MOISTURE IN THE HOME

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ABSTRACT

Ventilation is a key factor in low energy housing. In temperate maritime climates such as Britain's moisture is a major factor in determining ventilation needs. Moisture criteria are outlined for both people and buildings. Moisture sources are summarised. Control can be achieved by either mechanical ventilation or heat pump dehumidification.

KEYWORDS

Ventilation, moisture, comfort, mechanical ventilation, advanced heat pump dehumidification.

INTRODUCTION

The space heating energy for a house depends upon three factors, the thermal transmittance of the fabric, the operating temperature pattern of the dwelling and the ventilation rate. The first factor can be calculated easily. The second can be identified by the occupants as too hot, just right, or too cold, and simple control equipment provided to regulate the temperature. The third factor, ventilation, is one of the most difficult to assess and the occupants have no knowledge of over-ventilation until the rooms actually become draughty. It is therefore this third factor which deserves our urgent attention. The success of low energy solutions depends upon some form of regulating ventilation in a more refined way than simply opening a window.

Over-ventilation wastes energy. Under-ventilation leads to odours and moisture problems inside the house. In a temperate maritime climate such as Britain's, severe condensation troubles are the major housing problem. Moisture control therefore becomes important for both energy conservation and for the longer term preservation of the building fabric.

This paper outlines moisture criteria for both people and the building itself, examines sources of moisture and reviews potential solutions.

MOISTURE CRITERIA

Let us consider the comfort and building preservation aspects of moisture.

(a) Comfort

Moisture affects comfort in several ways (Raiss, 1968; Fanger, P.O., 1970; Winslow, 1942; McIntyre & Griffiths, 1975; Gaul & Underwood, 1952; Brundrett, 1977; Lake & Lloyd-Hughes, 1980). For some problems the key parameter is the water vapour pressure or absolute humidity; for others it is the relative humidity. Breathing is an example where vapour pressure is critical. Exhaled breath tends to be near to body temperature and saturated with water vapour from the lungs. The water loss from the person is then related to the difference between this constant value and the ambient vapour pressure. Laboratory studies on dry throats support this and a suggested relationship is given in figure 1. This means that lower relative humidities are more acceptable at higher air temperatures. The same is true for problems of skin cracking which occur in extremely cold and hence extremely dry climates. High humidities can also induce sensations of sultriness or in extreme cases clammy foreheads. These characteristics are also closely related to water vapour pressure.

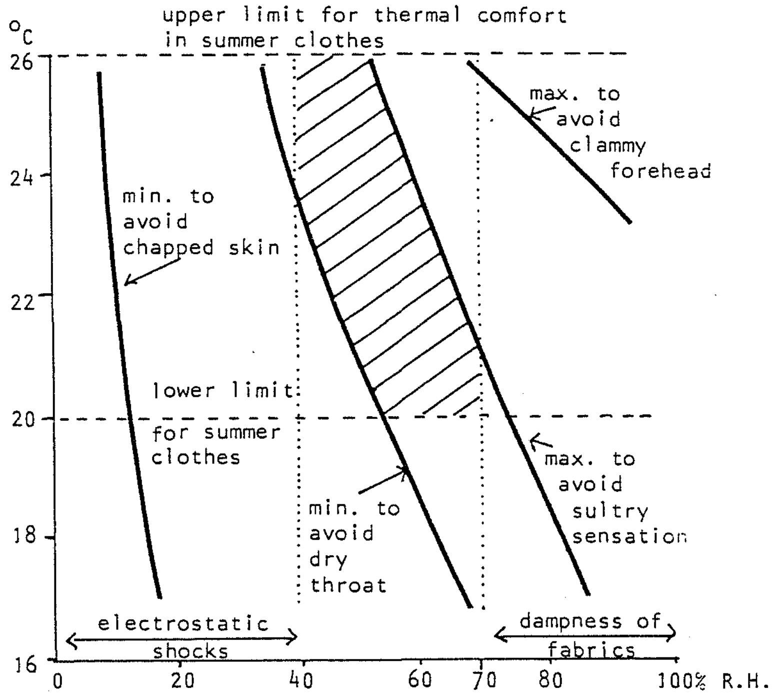

Fig. 1 Comfort zone for sedentary people (shown hatched)

Humidity has little effect on warmth in normal sedentary comfort. However, it becomes very important in hot conditions when comfort depends upon evaporative cooling from perspiration. In this overheating state lower humidities are favoured.

The moisture content of organic materials such as wood, cotton, wool, paper and leather is mainly related to the relative humidity of the atmosphere, rather than the absolute humidity. Carpets, for example, become less electrically conducting in atmospheres of low relative humidity. In these circumstances, particularly below 40% r.h. electrostatic shocks can be created by walking about and then touching earthed objects such as a metal door handle. Similarly, at increasing relative humidities these organic materials absorb progressively more and more moisture. Eventually materials such as clothing and upholstery feel damp. This occurs at relative humidities above 70%.

Finally there can be indirect effects of dampness on comfort. Certain sensitive individuals develop an allergic asthmatic response to the house mite. This mite is almost too small to see but thrives in damp, warm conditions. Studies link the mite population closely with dampness (Varekemp et al., 1966), figure 2. Fortunately mites only develop above 70% r.h.

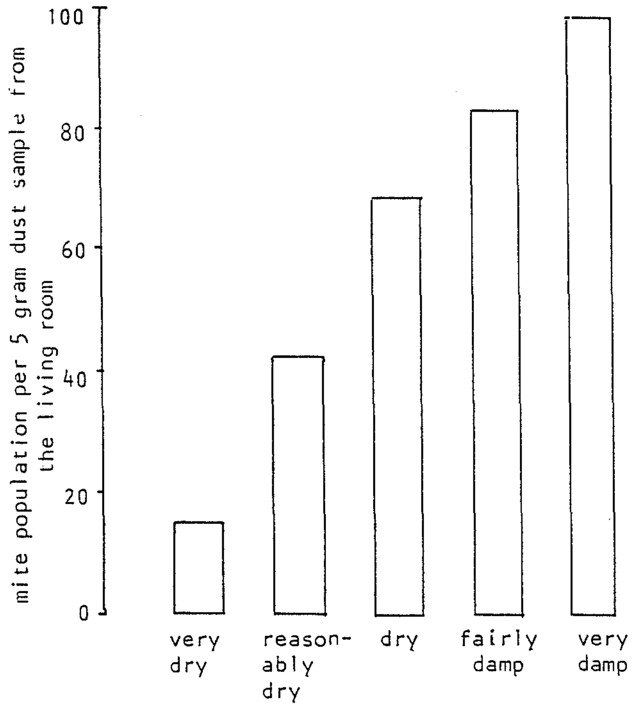

Fig. 2 Mite population as a function of subjective assessment of house dampness (Varekamp et al. 1966)

(b) Building protection

Dampness encourages mould growth which eventually leads to deterioration of building components such as wallpaper, plasterboard and timber. The mould develops from spores which are ever-present in outdoor air and quickly settle in all houses. Since nutrient is plentiful, once suitable conditions of moisture and temperature occur, then mould will grow. The time for spores to germinate varies widely with temperature and relative humidity. Below certain relative humidities, usually 70%, the spores will not germinate. All houses contain a wide variety of species of mould spore which develop best over a range of temperatures. The germinating characteristics of one common mould, Penicillium chrysogenum is illustrated in figure 3. (Groom & Panisset, 1933). Other moulds behave similarly although the optimum temperature varies with type.

Timber is particularly sensitive to deterioration in the damp and it is essential that structural timber does not exceed 20% moisture by weight. This is equivalent to an ambient relative humidity of 85%.

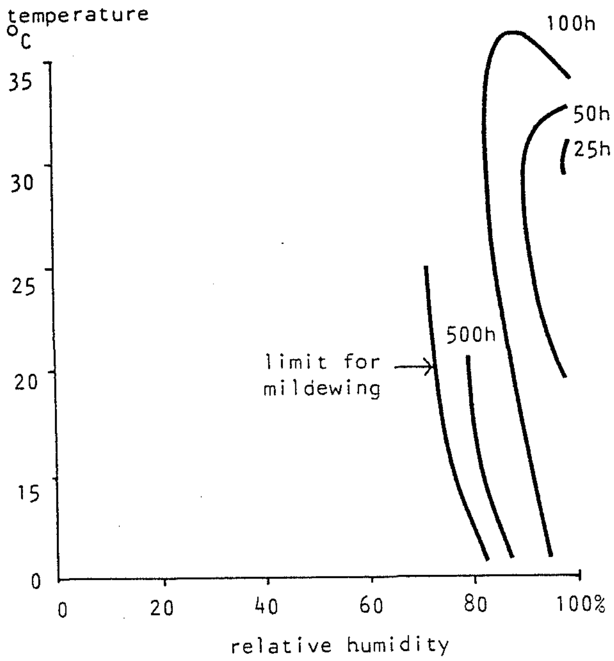

Fig. 3 Germination time for the domestic mould Penicillium chrysogenum (based on data from Groom & Panisset 1937)

It is important to prevent mould from becoming established. Once mould starts to grow then one of the by-products of its metabolism is water. Established mould can therefore continue to grow even when the ambient conditions are too dry to germinate mould spores elsewhere.

Moisture diffusion through the walls and roof also has to be considered. Many of the thermal insulants permit water vapour to pass easily through them. This can result in interstitial condensation unless an appropriate vapour barrier is positioned on the warm side of the insulant. Moist air penetration of the loft space must also be prevented.

MOISTURE GENERATION

One major feature which distinguishes occupied houses from unoccupied test houses is the persistent generation of water vapour inside the house. There are many sources but the three major daily ones are from cooking, from the people themselves, and from washing and bathing (Fournol, 1957; Smith et al., 1948; Loudon, 1971).

The water losses from cooking depend partly upon the type of cooker and partly on the housewife's cooking habits. American gas cooker studies found 2 kg of water was released during a normal day of which 58% came from the gas burner itself. The housewife's habits are influential not only in frequency of use and duration of cooking but particularly in the use of saucepan lids (Brundrett & Poultney, 1979) The presence of a saucepan lid during normal simmering operations reduces the moisture released by a factor of 100 and reduces the energy consumption by 80% of that without a saucepan lid. Baths, showers and dishwashing create a further 1 kg/day. Showers are particularly high in moisture release (0.2 kg) compared with a bath (0.05 kg).

Clothes drying, although normally an outdoor activity, poses the biggest single moisture load in a house. If clothes are washed and dried indoors, a further 8 kg of water is released in the house. This exceeds the total of all other sources.

Estimates of moisture release are summarised in Table 1. Local flueless heaters such as portable paraffin fires, create more water vapour than paraffin burned (water release = 1.25 x paraffin consumed). This is in addition to high emissions of carbon dioxide.

TABLE 1 Moisture generation rates in houses

Activity	AUTHOR		
	Smith 1948 (11) USA	Fournol 1957 (10) FRANCE	Loudon 1971 (12) ENGLAND
Family size	4		5
Personal evaporation per hour per day	 5 kg	 50-80 g/h	 1.7 kg
Floor mopping	~ 1 kg per kitchen	-	-
Clothes washing Clothes drying	2 kg 12 kg/week		0.5/day 5 kg/day
Cooking Breakfast Lunch Dinner	15 kg/week* 0.4 kg 0.5 kg 1.2 kg		3 kg/day (gas)
Baths Shower Tub	 0.2 kg 0.05 kg		 1.0 kg/day (incl.dishes)
House plants	0.02 kg		
Daily quantity	25 kg washday 11.4 kg av.	// 10 kg light 26 kg medium 42 kg heavy	15.4 washday 7.2 average

// Calculated for 216 m^3 dwelling based on release rates of 2 g/h, 5 g/h and 8 g/h.
* 42% from food, 58% from gas cooker.

Trends towards wider use of showers will increase the moisture burden. Trends towards automatic clothes washing machines with spin dry action will increase the drying burden compared with high speed spin drying. Trends towards tumble dryers will reduce the risk of moisture release in the house provided such machines are vented to the outside. Dishwashers now condense all their steam inside the appliance.

VENTILATION CONTROL OF MOISTURE

Since moisture is constantly being generated inside the house, the humidity will always be higher inside than outside. Outside air can therefore be introduced into the house to dilute the moisture concentration. However Britain's climate has almost saturated air for the whole of the winter (Heap, 1973). The absolute humidity therefore closely follows the average outdoor temperature (figure 4). The amount of ventilation will therefore vary with the season. In cold weather the outdoor air will be dry and not much of it will be needed. In mild weather the outdoor air contains much more moisture and therefore much more of it will be needed.

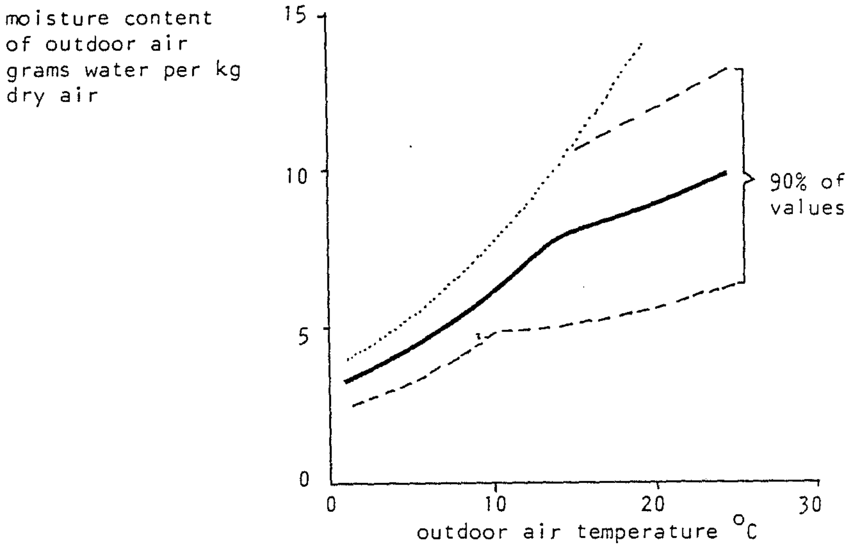

Fig. 4 Variation of humidity with temperature (Heap, 1973)

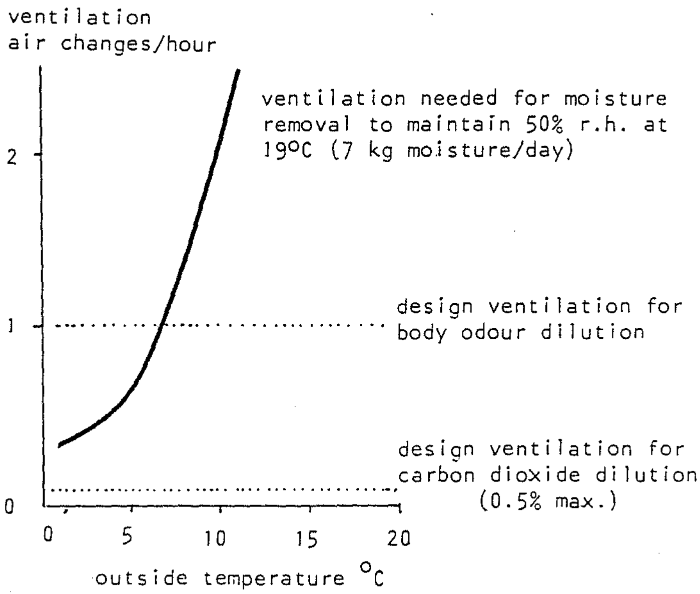

Fig. 5 Ventilation needs for moisture and odour control

An illustration of the seasonal change in ventilation needs is given in figure 5 (Agius, 1979). Higher ventilation values will be needed if the house temperature is colder.

Positive supply and extract ventilation systems for the whole house are now being manufactured in quantity and with the added provision of heat exchange (approx. 65% effective) between the inlet and extract supplies. This solution is an attractive low energy one, but the air supply is manually controlled. In temperate climates provision for a variable speed unit controlled by indoor relative humidity would be a desirable option.

HEAT PUMP DEHUMIDIFICATION

An alternative moisture control method to ventilation dilution is heat pump dehumidification (Blundell, 1978). Vapour compression refrigeration techniques are already widely used for moisture extraction. Such units stand within the room and recirculate the room air. This air is drawn in over the evaporator heat exchanger and is cooled down below its initial dew point. Some moisture is then condensed and runs to waste. The same air, now cold and dry, then passes through the condenser heat exchanger and finally over the compressor itself to extract all the useful heat. Cool, damp air is therefore transduced into warmer, drier, air.

The net heating effect of the dehumidifier on the room air is greater than that which would be estimated from the electricity consumption alone. The extra heat is from the latent heat of the condensed moisture.

Recent developments in the heat pump cycle include the addition of an air to air heat exchanger. Thermodynamically this produces a significant improvement in performance with coefficients of performance of 2.0. Small, low powered electric dehumidifiers are now possible to remove moisture within the house while providing background heating.

The improved performance characteristics of the new dehumidifier are illustrated in figure 6.

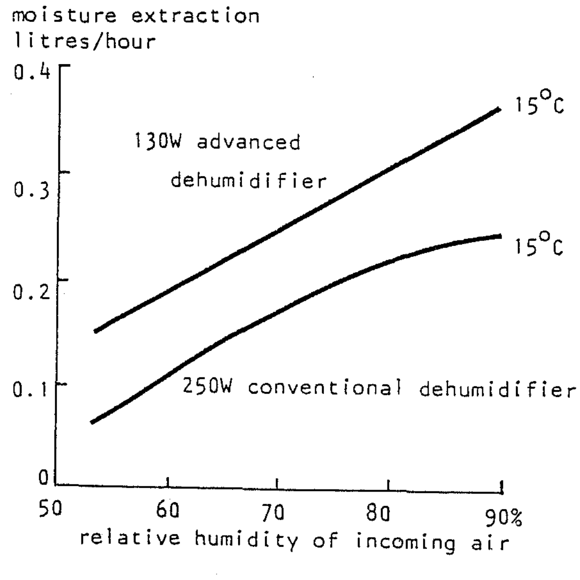

Fig. 6 Performance characteristics of heat pump dehumidifiers

CONCLUSION

Ventilation is particularly important in low energy housing. One of its main functions in temperate maritime climates is to control moisture levels.

Design strategies should minimise moisture release in the home and also regulate the humidity in the house. This can be achieved by either mechanical ventilation systems with heat recovery or by heat pump dehumidification.

REFERENCES

Agius, P.J.V. (1979). A warmer house at lower cost. Watt Committee on Energy, London.

Blundell, C.J. (1978). Improving heat pump dehumidifiers. Heating and Ventilating Engineer, 52, 5-7.

Brundrett, G.W. (1977). A review of the factors influencing electrostatic shocks in offices. Journal of Electrostatics, 2, 295-315.

Brundrett, G.W. & Poultney, G. (1979). Saucepan lids: the key to low energy cooking. J. Consumer Studies & Home Economics, 3, 195-204.

Fanger, P.O. (1970). Thermal comfort. Danish Technical Press.

Fournol, A. (1957). Ventilation et condensations. CSTB Report 28.

Gaul, E. & Underwood, G.B. (1952). Relation of dewpoint and barometric pressure to chapping of normal skin. J. Int. Dermatol. 19, 9-19.

Groom, P. & Panisset, T. (1933). Studies on Penicillium chrysogenum. Ann. Appl. Biol. 20, 633-660.

Heap, R.D. (1973). Heating cooling and weather in Britain. ECRC/M631.

Lake, B. & Lloyd-Hughes, J. (1980). Perception of moisture. To be published in the Journal of Consumer Studies and Home Economics.

Loudon, A.G. (1971). The effects of ventilation and building design factors on the risk of condensation and mould growth in dwellings. Architects Journal, 153, (20), 1149-1159.

McIntyre, D.A. & Griffiths, I.D. (1975). Subjective response to atmospheric humidity. Env. Res. 5 (1), 66-75.

Raiss, W. (1968). Heiz und Klimatechnik. Springer-Verlag, Berlin.

Smith, J.M., Blome, C.E., Hauser, H., Eades, A. and Hite, S.C. (1948). Research in home humidity control. Purdue Univ. Prof. BGR 8C. Research Series 106.

Varekemp, H., Spieksma, F.Th.M., Leupen, M.J. & Lyklema, A.W. (1966). House dust mites. Paper 2.56 Interasma V Congress, Utrecht.

Winslow, C.E.A. (1942). Physiological influence of atmospheric humidity. JIHVE 9, 369-376.