DEPARTMENT OF THE ENVIRONMENT ALC 1359

Building Research Establishment

1941

Scottish Laboratory
Kelvin Road East Kilbride Glasgow G75 0RZ
Telephone East Kilbride 33001 (STD Code 035 52)



# THE EFFECTIVENESS OF REMEDIES TO SURFACE CONDENSATION AND MOULD

by J P Cornish, C H Sanders and J Garratt

SUMMARY

Surface condensation and mould affect about 15% of the UK housing stock. This paper reports BRE work undertaken in occupied dwellings to identify the effectiveness of a range of remedial measures in various situations. The remedies investigated include the improvements to insulation levels, and heating systems, the provision of extract fans and dehumdifiers. The studies were undertaken in both flats and 2-storey houses, all of traditional construction with brick walls and pitched roofs.

Results are given both of changes in internal environment and energy consumption associated with the different measures. The results are currently being analysed to provide practical guidance on the identification of effective measures to solve condensation problems in other dwelling types.

# THE EFFECTIVENESS OF REMEDIES TO SURFACE CONDENSATION AND MOULD

by J P Cornish, C H Sanders and J Garratt

## INTRODUCTION

Dampness is a major problem in UK housing. Best estimates put the number of dwellings affected by severe dampness at 2 million, with a further 2.5 million affected to a lesser extent. The major cause is condensation which often leads to mould growth. The figures indicate that about 1.5 million dwellings suffer from minimal mould growth, another 1.25 million have more severe problems and a further 0.25 million have extensive mould growth, often causing acute anxiety to the householders and giving rise to serious complaints. These problems are widespread in all housing sectors but are most serious in tenanted accommodation, both private and public.

Having diagnosed the dampness or mould problem as due to condensation, information is then required to determine the most cost-effective treatment for the particular case in hand. There are treatments for mould growth, such as fungicides or anti-condensation paints, which can be useful for mild attacks or as short-term measures. In the long term, however, cures must concentrate on the elimination of condensation.

In order to provide better advice on the effectiveness and cost of remedial measures likely to be adopted in traditional dwellings, BRE have been carrying out trials of different remedies in occupied dwellings in Scotland and England. All the estates had a history of complaints of dampness. Results of the trials are still being analysed, but they have given some useful pointers to the effectiveness of different measures in varying situations. The remedies which have been tried out, either on their own or in combination, are insulation of external walls by cavity-fill or by externally applied insulation, new partial or full central heating systems, extract fans in kitchens and bathrooms controlled either by the householder or by humidistat, and dehumidifiers.

In Scotland one set of field studies was carried out on an estate of four-storey, two and three-bedroom flats in Stirling. The construction is traditional with brick-cavity-brick walls and pitched roofs. All top floor flats had 75 mm of insulation in the roof space. The concrete floor to the living room extended to form a balcony and possibly a thermal bridge, this was not as important a condensation problem as the single leaf brick wall between the bedrooms and the open stairs. Originally underfloor heating had been installed in the living room and hall only, this was very rarely used either due to failure of the system or because the householders found it expensive to run: a large number of the householders had resorted to using paraffin or bottled gas. About three-quarters of the householders had complained of condensation or mould. Eighty flats were involved in the trials, divided into five groups of 16. One group was left as control, the remainder were modified:

- improved insulation - external cavity walls were filled with polystyrene beads

- improved ventilation - extract fans in kitchens and bathrooms controlled by the householder

- improved ventilation - extract fans controlled by humidistat which switched on when the relative humidity rose above 70%

- improved heating, insulation and ventilation - a gas group heating system served radiators in all rooms, thermostatic radiator valves were set at 12°C. Cavity walls were insulated as before, and bedroom walls adjacent to the stairs were dry-lined. Extract fans either under householder or humidistat control were also fitted.

In England the field studies were undertaken at Harrow, Middlesex in an estate of traditional 1920's two-storey, semi-detached and terraced houses. The construction is 225 mm solid brick walls, timber floors and tiled pitched roofs.

Twenty houses were monitored both before and after remedial measures were undertaken.

The remedial packages that were investigated were:

- fifteen houses with external wall insulation added, gas fired partial central heating installed and extract fans fitted in kitchens and bathrooms

- five houses with a full gas central heating system installed throughout the house - no insulation was added to the walls.

Additionally field studies were undertaken in 30 flats at Inverclyde, Strathclyde and in four two-storey houses at Harrow to investigate the performance of some free-standing dehumdifiers.

Monitoring in all cases involved determining the temperature and relative humidities in kitchens, living rooms and one bedroom of each dwelling, together with external conditions. Of particular concern are the periods when relative humidity exceeds 70%. Above this value conditions are favourable for mould germination and, once germinated, can easily be sustained. Energy consumptions and the length of time extract fans and dehumidifiers ran were recorded. The amount of water collected by the dehumidifiers was noted by the householders.

Although the data from the field studies are still being analysed some useful pointers have been given of the effectiveness of the different remedial measures in varying situations.

Extract fans  Table 1 gives the average run times of the extract fans at Stirling. Fans under tenant control were rarely used and results confirm that they had little or no impact on conditions in the flats. In those flats where the installation of humidistat controlled fans was the only modification, they ran for almost a third of the week. The percentage of time that the relative humidity exceeded 70% in each room in the different groups is shown in Table 2. It can be seen that, except in the living room which adjoined the kitchen, the effect of the fans is small. The limited effect of the fans at Stirling is thought to be caused by the fan being too small. The fans controlled by humidistats also ran very little in the group heated flats, because the relative humidity rarely rose above 70%.

In the Harrow trials fans were fitted to all the houses as part of the modernisation package. They were not greatly used but the indications are that they helped improve conditions.

Thermal insulation  Mean temperatures and humidities for each room averaged over all the flats and over the whole monitoring period were calculated for each group of flats at Stirling. Fig 1 shows a comparison of the control group with the flats with cavity wall insulation. As expected kitchens and living rooms which are heated are warmer when insulated. However, the bedrooms are very little different. Not unusually, in these flats the bedrooms are located above each other with few heat gains from living rooms and kitchens that occur in two-storey houses. Thus, if the bedrooms are not heated, the insulation will confer little benefit.

The results from these flats indicate that vapour pressures (air moisture contents) are higher in the insulated kitchens, one of the main sources of water vapour in the flats. A possible cause is a reduction in adventitious ventilation by the sealing of cracks when the cavities were filled. There is little difference in the moisture contents in living rooms and bedrooms.

Table 2 shows that insulation (at a cost of £200 per flat) has reduced the risk of mould growth in heated rooms but made little difference to unheated bedrooms.

In the 2-storey houses at Harrow which were modernised with external insulation, partial central heating and extract fans the whole house temperature rose by 4.2°C. The risk of condensation was virtually eliminated even in the nominally unheated bedrooms and the great majority of the householders were satisfied with the modifications.

Results indicate that insulating the building fabric is likely to have a significant effect on temperatures in unheated bedrooms of two-storey houses or maisonettes but only have a minimal effect on the bedrooms in flats or bungalows. In these latter cases heating must also be provided.

Heating and insulation  As expected, all the rooms are much warmer in the insulated flats with full central heating. The effect is most striking in the bedrooms which are completely removed from any risk of condensation or mould growth (Fig 2). Table 2 indicates that the relative humidity in these flats virtually never rose above 70%.

The results indicate a fall in the moisture content of the air in the living rooms. This may be due to increased ventilation caused by the householders' preference to open windows. Even so, the average winter fuel costs of gas for space and water heating, and electricity for cooking and power, was £9: this compares with the £10.50 the householders paid in the all-electric unmodified flats.

Although the cost of the external insulation at Harrow was £1400 per house, against this must be set the saving on the cost of the central heating system which only served radiators in the downstairs rooms. Additionally, the cost included rendering which would have been undertaken as part of rehabilitation in any case. Under these circumstances external insulation becomes economically much more attractive.

Results from these studies indicate that heating and thermal insulation should be considered as a package since this can result in a lower capital cost as well as a reduction in running cost.

Dehumidifiers The field studies undertaken on dehumidifiers at Inverclyde and Harrow have emphasised that dehumidifiers are essentially different from the other remedial measures because to succeed they need the active participation of the householder. The machines tested needed regular emptying of the water collected and were noisy and bulky.

Results from the trials indicate that the performance of dehumidifiers is critically dependent on the ambient conditions in which they operate. They perform well at high temperatures and high moisture contents. For example, in a well heated bedroom of a flat where the problems were due to high moisture generation, the dehumidifier reduced the relative humidity by reducing the moisture content of the air (Fig 3). In a poorly heated bedroom the dehumidifier had little effect on the moisture content but lowered the relative humidity by raising the temperature: it acted as a small (300W) and expensive (£300) heater.

At Inverclyde dehumidifiers were used in bedrooms of the flat as there was no room for them elsewhere. Machines extracting 4 litres of water per day reduced the risk of condensation in all rooms, while those extracting only 1 litre per day made little difference to relative humidity but the householders stated that they helped to dry damp carpets and bed clothes.

At Harrow the dehumidifiers were located downstairs in the kitchen or hall. The noise and location of the machines may explain why the average running cost at Inverclyde was about £1.10 per week, whereas at Harrow it was between £3 and £4.

Although the machines tested did not look very promising, new low-powered machines are now being developed which are more efficient and quieter.

## Energy and Capital Costs

In order to put the results of the flats at Stirling into context they have been plotted in Fig 4 on a graph of total annual energy consumption against fabric transmittance (ie the heat loss through the building fabric). The solid lines are derived from a survey of some 1500 local authority dwellings in Scotland. These show, not surprisingly, that fuel usage for average and higher users falls with decreasing fabric transmittance (eg with improved insulation). However, in the case of the lowest 25% of users fuel consumption is independent of the heat loss through the building fabric. This implies that the benefits of insulation are likely to be taken as increased temperatures and thus reduce the risk of condensation.

The results from Stirling indicate that there is very little difference in energy consumption in the flats when insulation alone was added though temperatures increased. In the flats with improved heating and insulation the average fuel consumption has moved from about the lowest 25% of fuel users to about average. The risk of condensation has been eliminated in these flats and the householders on average now pay about £1.50 less per week for energy.

Any remedial measures must be effective at a cost which is affordable by the householders. Fig 5a indicates the costs of remedial measures in a typical flat at Stirling with a heat input of 2kW, moisture generation of 7 litres per day and a ventilation rate of 1 air change per hour. In this typical flat the relative humidity would be about 80% and the flat at risk of condensation and mould growth. To remove the risk of mould growth the relative humidity can be reduced to 70% by either filling the cavities of the flats (at a cost of, say, £200-£300) or by the householder spending more on fuel (about £60-£150 per annum depending on fuel and tariff).

Fig 5b illustrates likely costs of remedies in a similarly heated flat but where the moisture generation rate is now assumed to be 14 litres per day and the ventilation rate 2 air changes per hour. In this circumstance the problem can be solved by the householder spending about £80-£220 pa extra on fuel. Cavity fill insulation could again be installed but this would not solve the problem and either the householder could pay an extra £30-£80 pa on fuel or internal or external insulation could be added to the already cavity-filled walls.

Results discussed in this paper are preliminary and analysis of the data is continuing. However, conclusions so far would indicate that:

- extract fans in bathrooms and kitchens are effective when controlled by humidistat; those under control of tenants are rarely used

- improved insulation reduces the risk of mould in heated rooms. In two-storey houses or maisonettes insulation of the building fabric results in increases in bedroom temperatures.. Conditions in unheated bedrooms of flats or bungalows are likely to be very little affected by insulation alone and heating is required

- the provision of insulation and heating eliminates the risk of mould growth. The cost of insulation can be offset by the reduced cost of the heating system and, consequently, heating and thermal insulation should be considered as a package

- the performance of free-standing dehumidifiers very much depends upon the conditions in which they operate. They are likely to work very well in well-heated dwellings where the problems are caused by high moisture generation rates or inadequate ventilation: they are less likely to be effective in other situations. Additionally, they require the active co-operation of the householder. Newer machines are being developed which may overcome some of these problems.

ACKNOWLEDGMENT

The work described has been carried out as part of the research programme of the Building Research Establishment of the Department of the Environment and this paper is published by permission of the Director.

The authors are indebted to the Councils and Tenants of Harrow, Stirling and Inverclyde, who permitted their houses to be monitored for these studies.

TABLE 1: Extract fans - running times (hours per week)

| | Humidistat controlled | Tenant controlled |
|---|---|---|
| Fans in flats with group heating and insulation | 3.8 | 1.4 |
| Fans in 'control' flats | 49.4 | 2.6 |

TABLE 2: Percentage of time relative humidity greater than 70%

| | Control | Fans (humidistat) | Insulation | Heating and Insulation |
|---|---|---|---|---|
| Living room | 16% | 1% | 0 | 0 |
| Kitchen | 20% | 14% | 8% | 0 |
| Bedroom | 62% | 43% | 35% | 0 |

FIG 1 COMPARISON OF CONTROL AND INSULATED FLATS

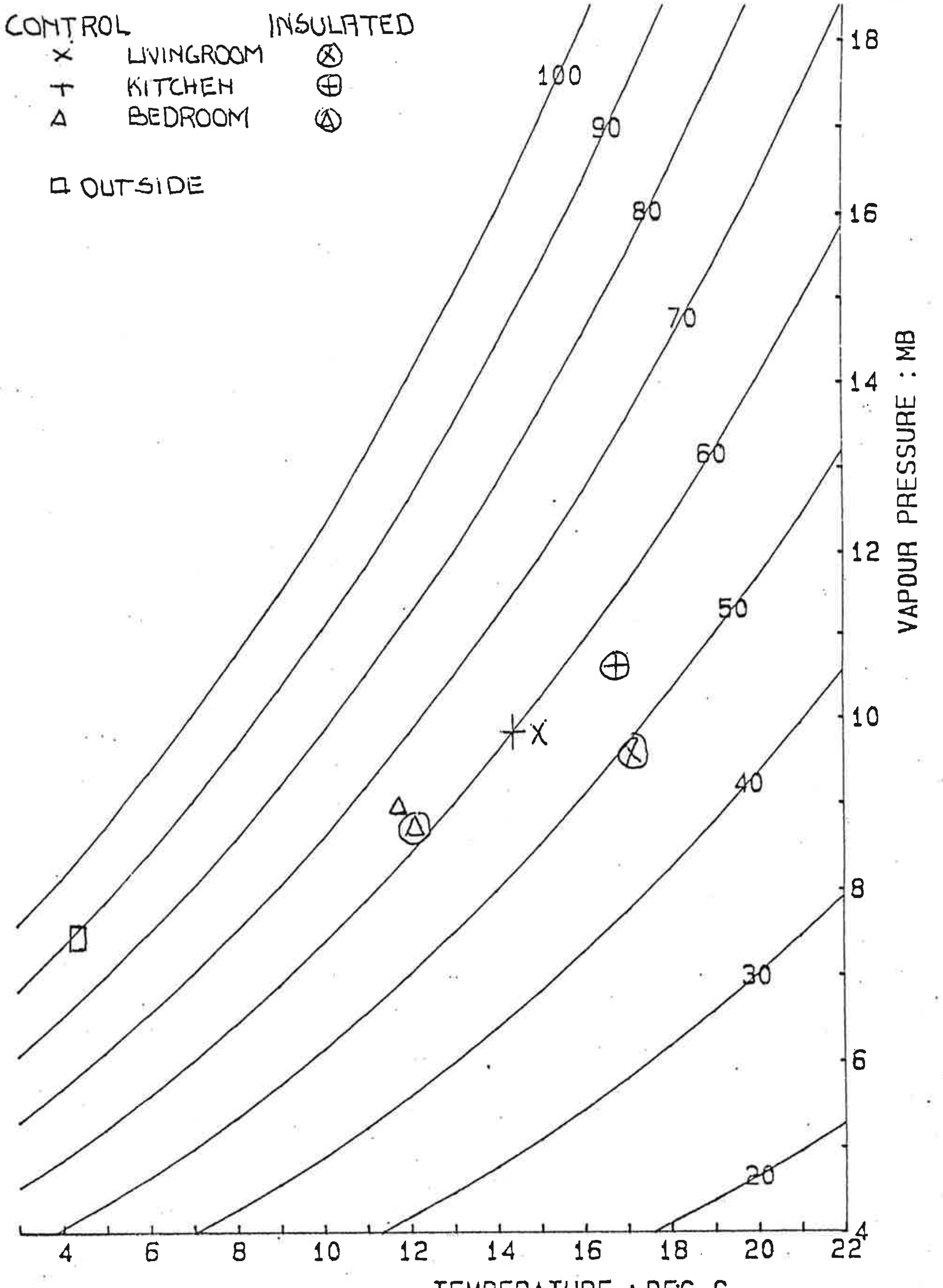

FIG 2 COMPARISON OF CONTROL AND GROUP HEATED FLATS

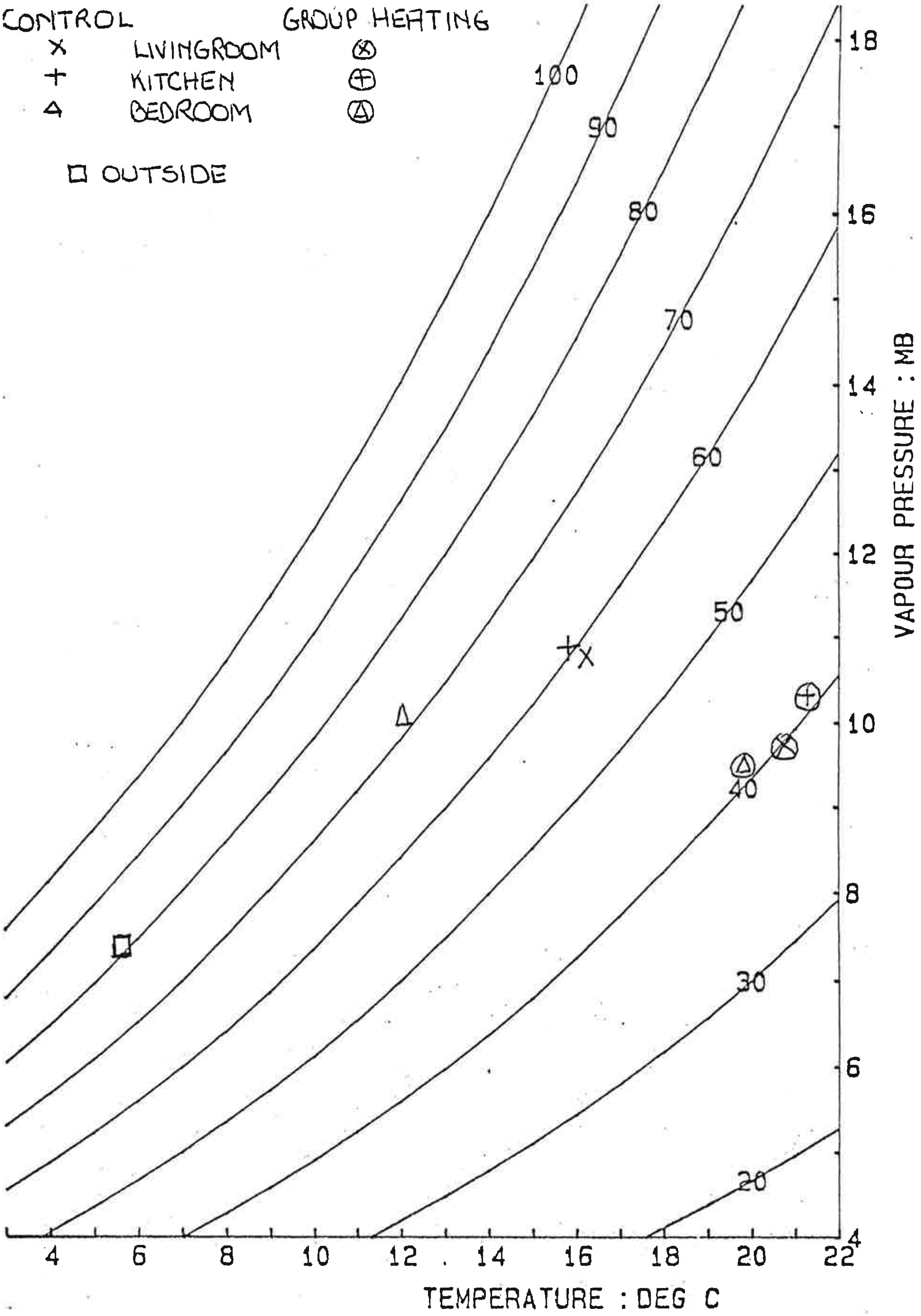

FIG 3 EFFECT OF A DEHUMIDIFIER RUNNING IN WARM AND COLD BEDROOMS

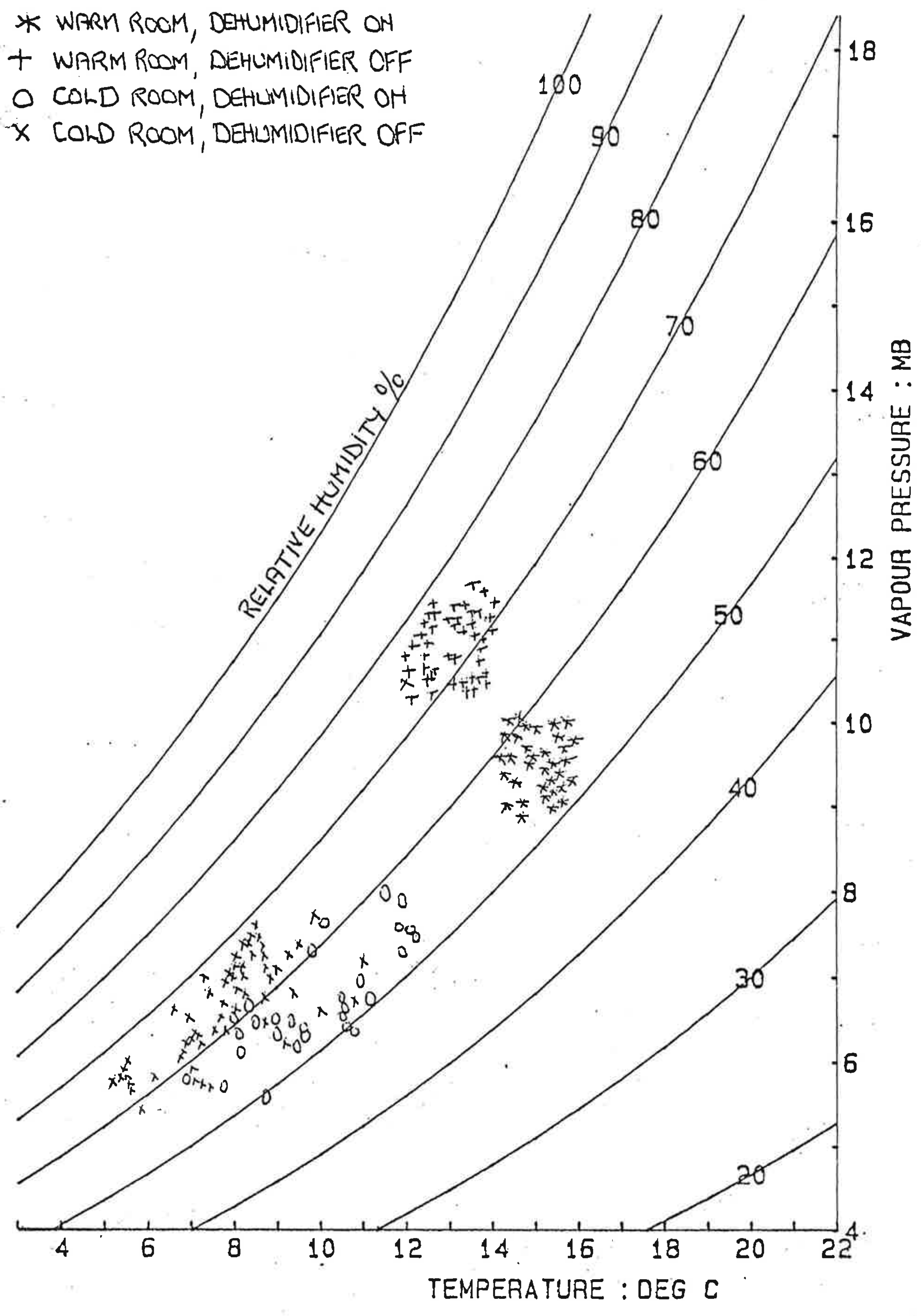

FIG 4 ANNUAL HEAT INPUT TO FLATS

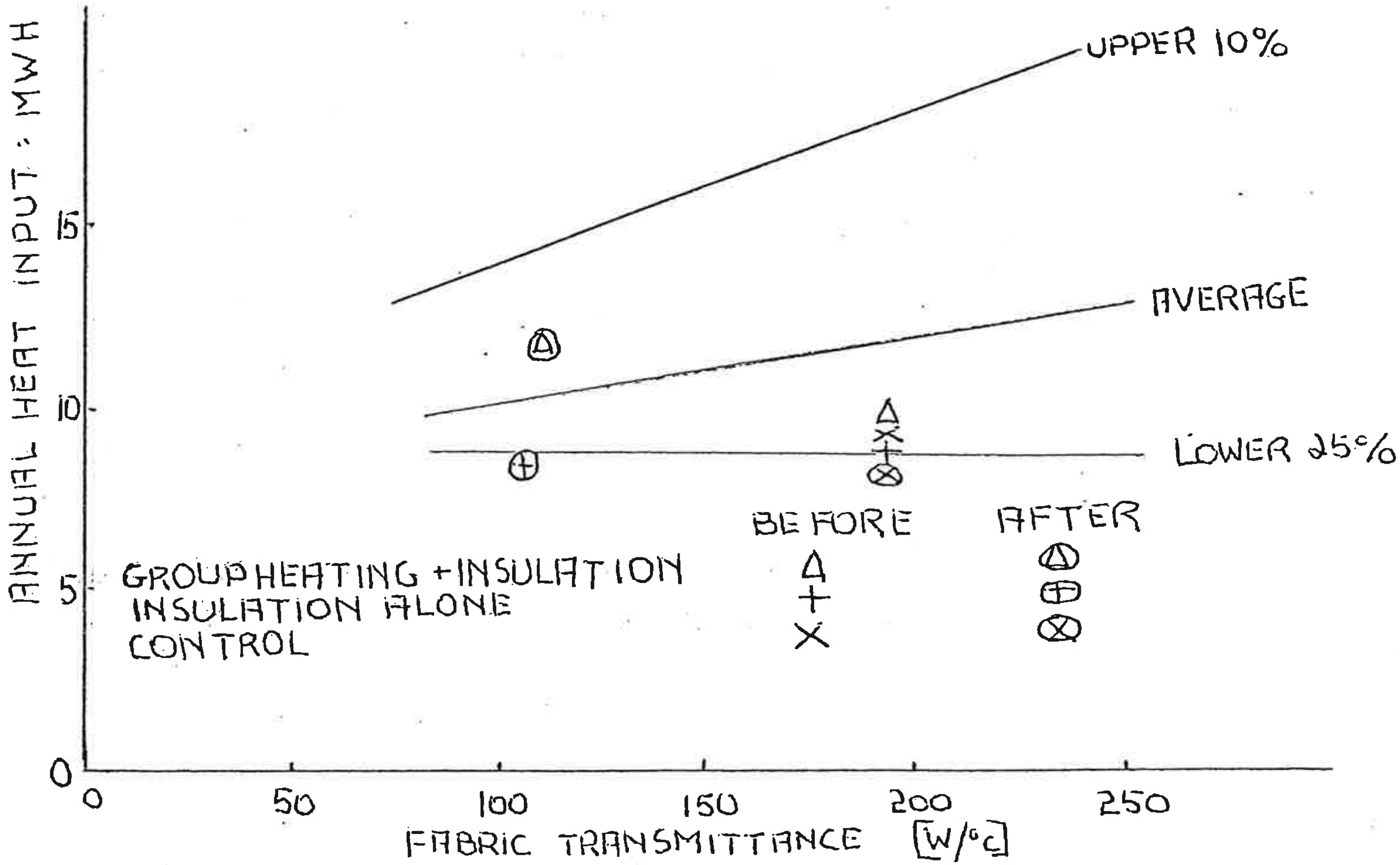

FIG 5(a) THE COST OF REMEDIAL MEASURES IN A TYPICAL FLAT AT STIRLING

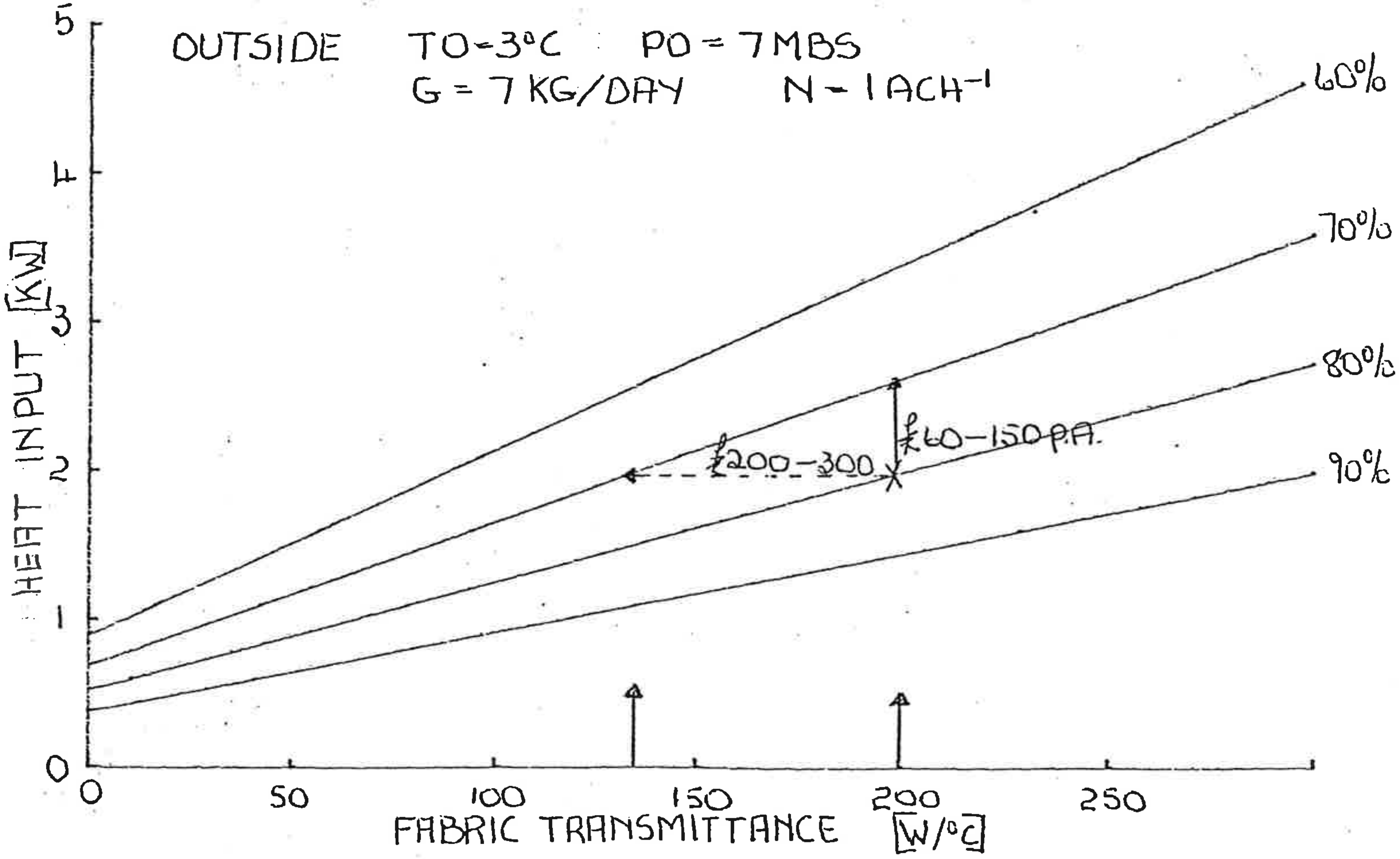

FIG 5(b) THE COST OF REMEDIAL MEASURES IN A FLAT AT STIRLING WITH HIGH MOISTURE GENERATION