THE EFFECTS OF UNSEALING THE WINDOWS ON COMFORT AND ENERGY CONSUMPTION (A CASE STUDY)

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In consequence of complaints about the indoor climate, resulting in increased absenteeism, the Dutch Governmental Occupational Health and Safety Service conducted an investigation in an office building. Several measures were advised to improve the situation. One of the measures was to unseal the windows. Specific care was taken to make sure that this would not result in an increase of energy consumption.
After the completion of these measures a follow up study was undertaken to evaluate the effects. The follow up consisted of an inquiry among the occupants with a specially designed questionnaire to evaluate their experience of comfort and monitoring of the energy consumption.
The results show that adjusting the HVAC in combination with unsealing the windows resulted in a reduction of the complaints and an increase of comfort without increasing the energy consumption.

INTRODUCTION

The office building in question has five floors and there are no adjacent buildings in the near surroundings. The majority of the workspaces are so called room-offices, that is with 2 to 6 occupants on approximately 10 m^2 per occupant. The airconditioning system consists of 10 different units each for half a floor. The air can be heated or cooled separately for each half floor. In the rooms the air is supplied alongside the facade through low inducing ventilation units combined with hot water radiators. The air is exhausted in the corridors and in cold and hot weather recirculation takes place. The outdoor sunblinds are controlled by a central unit. In order to economize energy consumption the windows had been sealed.
Ever since the occupation of the building by governmental services in 1984, occupants have been complaining of too high and too low temperatures, draughts, temperature swings and poor air quality.
An investigation was conducted by the Dutch Governmental Occupational Health and Safety Service, the Department of Research and Development to illuminate causes of the complaints and to advise adequate measures for improvement of the situation.

INDOOR CLIMATE INVESTIGATION

Method

The performance of the installation has been monitored by extended indoor climate and ventilation measurements during three weeks in the winter period and three weeks in the summer period. In six representative rooms air temperature, mean radiant temperature, air velocity, air humidity and the CO_2-levels where measured continuously. Furthermore, the prevalence of micro-organisms in water and isolation materials of the humidification section were obtained and analyzed.

Results

Analysis of indoor climate parameters in the winter-period exhibited no deviations of recommendations of PMV-values (ISO 7730, 1984). In a few rooms, results displayed exceed the draught limit (10% Percentage Dissatisfied). On average the CO_2-level did not exceed the CO_2-limit value of 0.10 vol.%. In two of the investigated rooms, the ventilation system did not meet this demand and CO_2-levels of 0.12 vol.% were found. In the summer period approximately the same values for draught and CO_2 values were found but PMV-values occasionally exceeded the +1.0.

The central airconditioning units were inspected visually. Because the filters, the humidifier section and the isolation material looked very polluted, samples for micro biological analyses were taken. The results showed 10^3 to 10^7 bacteria/ml and also mouldgrow. The isolated material also contained moulds. Immediate action was taken to clean the entire system because it was likely that some allergic reactions and even more serious diseases could result from this pollution, although the complaints that were the motive for the investigation were not expected to be caused by the micro biological contamination.
No chemical measurements were undertaken because the complaints as well as the situation gave no cause for this.

Advised measures

In the winter period the offices were draughty due to the high air velocities. It was decided that the air velocity should be lowered. Because this could result in a reduced fresh air supply the maximum recirculation was lowered from 80% to 50%. It was also decided to unseal the windows because it was hypothesized that the window ventilation would further compensate for the possible reduction of mechanically supplied air. Above that, ventilation is then available at the moments the occupants need it. (This solution is only adequate when the room sizes and the number of occupants are small). It is often expected that this will increase the energy consumption. The results of the evaluation will show that this is not the case.
The same measures were chosen for the summer situation, but another measure was added. To reduce the draught complaints even further and to reduce the energy needed for cooling, the existing situation of control on a steady room temperature level was changed. The new situation now has a minimum supply air temperature of 18°C combined with a maximal difference between supply air and outdoor temperature of 5°C. This measure, combined with the lower air velocity, reduces the amount of

cooled air in the rooms. It would now seem that due to this and together with a higher sun load the indoor climate would become too warm. But again the unsealed windows give the occupants the opportunity to compensate for this and to control their environment according to their own needs. Obviously this is a choice of human control over technical control. This is in accordance with other investigations (Landrus, 1987).
Theoretically this could also result in a more fluctuating temperature level, but the fluctuations now were controlled by the occupants. Important is that the unsealed windows were equipped with proper settings so that people can control the amount of incoming fresh air depending on their needs and weather conditions.

EVALUATION

Occupant satisfaction

Since there had been no systematic inquiry of the occupants complaints before the completion of the measures, only a posttest could be carried out. The posttest consisted of an inquiry approximately one and a half years after the completion of the measures among the occupants who had experienced the former situation and who had not changed worksite (N=65). In the questionnaire they were asked to compare the present situation with the situation before the measures were taken and to indicate if they now had less, the same amount or more complaints about several aspects of thermal comfort and air quality. The results are shown in table 1.
They were also asked to give a total judgement of the present indoor climate in comparison with the former situation. The results are shown in table 2.
The results clearly show an overall reduction of the complaints. Of specific interest is that the combined measure of less cooling and unsealing the windows resulted in reduction of the complaints 'too cool' as well as 'too warm' in the summer.
The results further show that in the new situation there are less complaints about air quality, probably due to increased individually controlled ventilation and the reduction of the amount of recirculated air.

Energy consumption

The energy consumption of the building consists of the use of gas for heating and electricity for cooling, lighting and other machinery and instruments. In figure 1 the gas use and degree-days during 1987, 1988 and 1989 are plotted. A degree-day is a factor that indicates the difference between the mean indoor air temperature and the actual outdoor air temperature.
The measures were taken during the summer of 1988. The data show that from that time on the gas consumption slightly decreased. The popular belief that unsealed windows lead to higher energy consumption is not corroborated.
We hypothesize that this is due to a more sensible use of the temperature controls and the windows by the occupants once they are given enough control over their indoor climate.
The total electricity consumption remained the same during the years 1987-1989. It was the impression of the technical

staff that in the new situation less electricity was used for cooling.

CONCLUSIONS

The results of the evaluation questionnaire show that after the measures were taken the number of complaints decreased significantly and that the occupants experienced the indoor climate more positively. The crucial point is the unsealing of the windows combined with adjustments on the HVAC system. In the winter period this results in less complaints about 'too warm', 'too cool' and draughts.
In the summer the theoretically warmer climate can be compensated by opening the windows. This is a more natural (human) way and gives greater occupant satisfaction. Also the air quality is experienced more positively.
The energy consumption did not increase.

This is a real life proof that buildings with a less artificial controlled climate cause less occupant complaints about thermal climate and air quality without increasing the energy consumption.

In the Netherlands and probably also in other countries there is a tendency to seal the windows of newly built buildings and leave the climate control almost exclusively to the HVAC system. The arguments for this 'solution' turn out to be highly debatable (Boerstra, 1990).

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Table 1. Judgement of occupants on thermal comfort and air quality after completion of the advised measures in comparison with the situation before the intervention

	less complaints	the same	more complaints
too warm in summer	39%	44%	18%
too cool in summer	47%	45%	8%
too warm in winter	40%	42%	18%
too cool in winter	49%	37%	14%
draught	29%	58%	14%
temperature swings	22%	56%	22%
stuffy air	34%	59%	6%
dust in the air	27%	71%	2%
dry air	20%	64%	16%

Table 2. Judgement of occupants on the indoor climate after completion of the advised measures in comparison with the situation before the intervention

better	42%
the same	45%
worse	13%

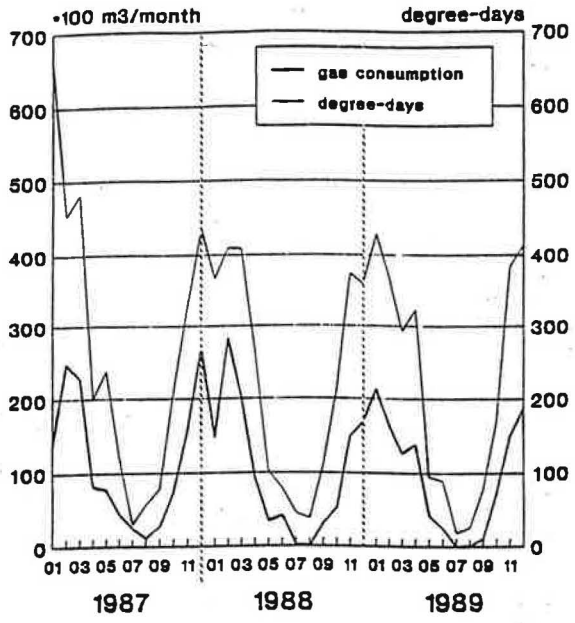

Figure 1. Gas consumption versus degree-days