Air Infiltration Review

a quarterly newsletter from the IEA Air Infiltration Centre

Vol. 7, No. 1, November 1985

# 6th AIC Conference Report

## Ventilation – the balance between Energy Efficiency and Well-Being sets the theme for the Air Infiltration Centre's 6th Annual Conference

In his keynote address to participants at the Air Infiltration Centre's 6th annual conference, Wolter Knoll, president of the Federation of European Heating and Ventilating Associations, focussed on the balance between energy conservation needs and ventilation requirements. In particular, it was pointed out that in some instances energy conservation measures had created new and unforeseen problems which now had to be solved. The key issues are firstly, how much ventilation is required to provide safe and comfortable conditions for building occupants and secondly, how can this ventilation rate be obtained and maintained. Referring to a study undertaken for the Dutch Ministry of Health, two components of contamination within buildings were identified, these being unavoidable and avoidable sources. The recommendation was that minimum ventilation rates should be based on unavoidable sources, i.e. those that were originated by the occupants themselves such as body odours, carbon dioxide and moisture. In principle all other sources of pollution should be restricted to such an extent that no health risks can occur, even at ventilation rates which are well below those required to meet the needs of occupants.


*Plate 1: Mr Knoll, keynote speaker at the AIC's 6th conference*

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The strategies for meeting ventilation needs were also outlined in the keynote paper. Although in principle it is not relevant whether air is supplied by purpose provided ventilation or by infiltration, the latter approach is unreliable since it varies according to weather conditions. For conventional Dutch houses, ventilation by infiltration was often found to be much higher than necessary, thus implying an uneconomic use of energy. On the other hand, modern 'energy conscious' houses tended to be very airtight with little air infiltration. Mechanical supply/extract systems were seen as the only solution for such dwellings.

While it was thought that mechanical ventilation provided the best opportunity for a constant air renewal in all rooms, it was emphasised that such a technique is often prohibited by costs, especially in dwellings. One approach being studied in the Netherlands, for new housing, is the introduction of an inexpensive yet effective combined air heating and ventilation system. The application of such a method to the existing building stock would, however, be uneconomic and instead remedial studies have concentrated on the importance of window opening to provide adequate ventilation. Research is being directed at analysing occupant behaviour in relation to window opening in an effort to devise guidelines for their optimum use.

The conference attracted a broad spectrum of papers with particular emphasis on ventilation strategies and measurement techniques. A number of important case studies and results relating to industrial and commercial buildings as well as dwellings were presented. In general, the ventilation strategies described varied according to climate. Methods for mild climates included the use of flues and atria to promote natural ventilation by stack action. In addition, the importance of window opening and the reactions of occupants to window opening was also emphasised. In severe climatic regions, approaches concentrated on advanced mechanical systems incorporating heat recovery and demand-related flow rates. Again, user interaction with such systems, as well as indoor air quality aspects associated with airtight buildings, formed important points for comment.

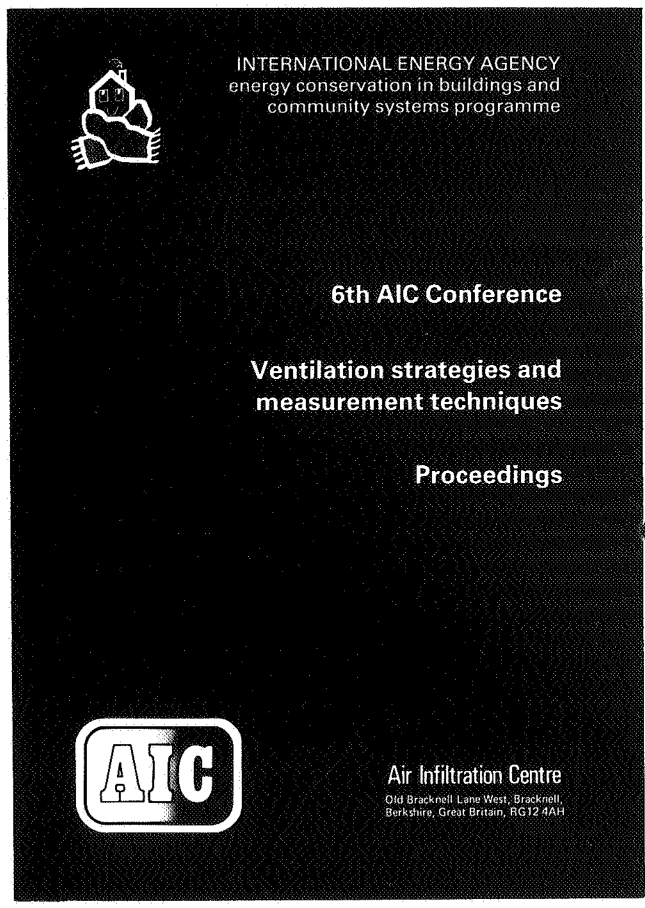
Developments in measurement techniques were largely concerned with tracer gas methods. This reflected the increasing use of tracer gas techniques, especially for measuring air infiltration in large industrial and multi-zone buildings. Techniques included the development of constant concentration methods for large single cell enclosures, multi-tracer methods for determining air movement patterns between zones, automated systems for occupied buildings, refinements to the constant concentration technique and the use of tracer gas methods to evaluate the performance of ventilation systems. Tracer gas and pressurization methods had also been used to determine the benefits of industrial building retrofit. Air leakage around loading bay doors was identified as a major infiltration route which could be very easily remedied by the use of weatherstripping. In one such case study, a reduction in the measured rate of air infiltration of 45% was achieved in this way.

Calculation techniques continue to play an important role in air infiltration analysis. Furthermore they are especially important in the development of new approaches to ventilation strategies. It was therefore appropriate that a session should be devoted to mathematical modelling methods. During this session, a summary was presented of the papers given at a multi-cell infiltration symposium held at the recent ASHRAE annual meeting in Honolulu. Other contributions dealing with modelling included the development of a simplified multi-zone model. One of the main points arising from the discussion on calculation techniques was increasing availability of air infiltration models on micro computers.

An important function of the AIC conference is to provide an international forum for discussion. On this occasion a total of 70 delegates representing all 12 AIC countries were present, with the result that a complete picture of the ventilation and infiltration problems as perceived by individual countries could be seen. Such a gathering provided the opportunity both to formulate new ideas and to put into perspective current research activities. Topics arising from the final discussion session centred on the accuracy of measurement methods and on the influence of occupants on building air change rates, both of which are very much in the forefront of future planning within the AIC. As regards measurement methods, the AIC plans to produce its own handbook (see Air Infiltration Review, Vol. 6, No. 4, August 1985), while IEA Annex VIII has for some time been investigating the influence of inhabitants on ventilation and the corresponding building energy requirements. Additionally, the AIC in conjunction with Annex VIII participants is planning a conference on occupant behaviour to take place next year (see separate Call for Papers).

In conclusion, the location for the conference at Het Meerdal Centre in the South-East Netherlands proved to be an excellent setting. The sports and social activities offered at the site provided an ideal opportunity for relaxation between conference sessions.

A total of 27 papers presented at the Conference have been published in a bound volume, price £22 sterling inclusive of postage and packing, available direct from:

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A supplement containing five additional papers and a report of the discussion will be available shortly at no additional charge.

# Call for Papers

## 7th AIC Conference 'Occupant Interaction with Ventilation Systems' 29 September – 2 October 1986 Location: England (venue to be confirmed)

**AIC's 7th Annual Conference to be held in collaboration with IEA Annex VIII.**

Energy use in buildings is greatly influenced by occupant behaviour, especially in relation to ventilation. Often the action by occupants results in ventilation rates much greater than really required, with the consequent waste of energy. On the other hand, too little ventilation, with attendant condensation and indoor air quality problems, can result from the maintenance of ventilation below the minimum requirement or by failure to respond to the intermittent need for increased ventilation.

The objective of this conference is to bring together those with knowledge or interest in this vital aspect of ventilation control with the intention of determining the key parameters governing occupant influence on building energy performance. Topics include:

- reasons for occupant's attitude and reactions to ventilation
- measurement of window opening habits or other ventilation control behaviour
- consequences of behaviour patterns on energy consumption and indoor air quality (case studies and calculations)
- user-acceptable ventilation strategies
- benefits of advice to user on ventilation control.

Abstracts of proposed papers on the above topics are welcome and should be received by the AIC no later than 21 February 1986. The abstracts will be subjected to review in March 1986 and print-ready copies of accepted papers will be required by 11 July 1986. Submissions from non-AIC or Annex VIII participating countries are welcome and, if the abstracts are accepted, the authors will be invited to participate in the conference.

The conference format will take the form of both author presentations and poster sessions – therefore interested authors should state their preference.

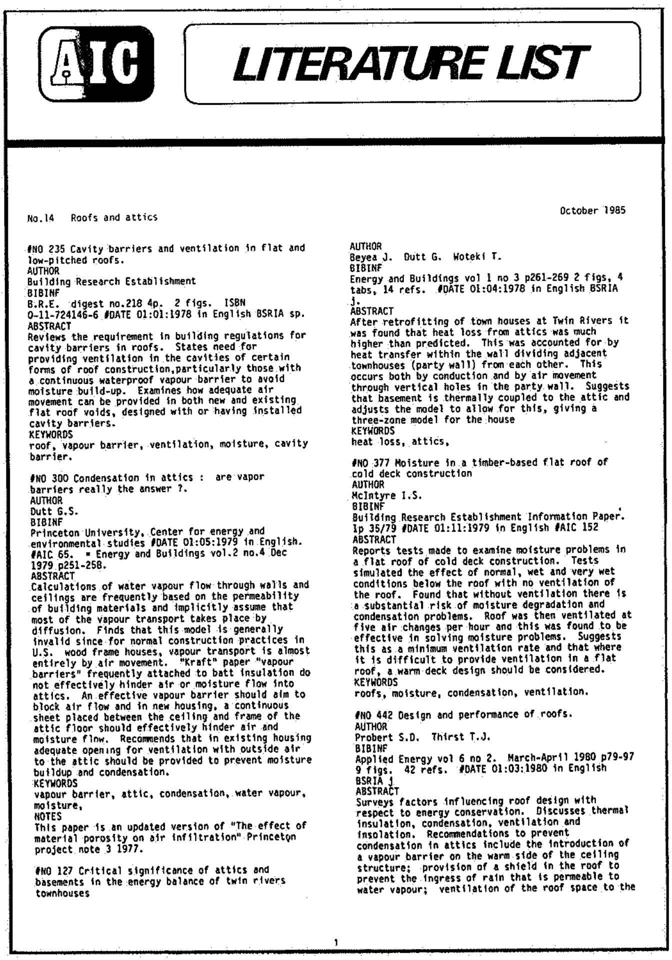
Programme and registration details will be published in the May 1986 edition of AIR. Booking forms will be obtainable from your Steering Group representative. Meanwhile, please reserve the Conference dates 29 September – 2 October 1986 in your diary.

## Literature List No. 14 Roofs and Attics

This is the latest in the AIC's series of literature lists. It contains abstracts and bibliographic details of 34 articles describing air infiltration and its effects on condensation in roofs and attics.

*Available free-of-charge to organisations in participating countries* only.*

**Belgium, Canada, Denmark, Federal Republic of Germany, Finland, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom and United States of America.*



AIC LITERATURE LIST

No.14 Roofs and attics

October 1985

#NO 235 Cavity barriers and ventilation in flat and low-pitched roofs.
AUTHOR
Building Research Establishment
BIBINF
B.R.E. digest no.218 4p. 2 figs. ISBN 0-11-724146-6 #DATE 01:01:1978 in English BSRIA sp.
ABSTRACT
Reviews the requirement in building regulations for cavity barriers in roofs. States need for providing ventilation in the cavities of certain forms of roof construction,particularly those with a continuous waterproof vapour barrier to avoid moisture build-up. Examines how adequate air movement can be provided in both new and existing flat roof voids, designed with or having installed cavity barriers.
KEYWORDS
roof, vapour barrier, ventilation, moisture, cavity barrier.

#NO 300 Condensation in attics : are vapor barriers really the answer ?.
AUTHOR
Dutt G.S.
BIBINF
Princeton University, Center for energy and environmental studies #DATE 01:05:1979 in English. #AIC 65. = Energy and Buildings vol.2 no.4 Dec 1979 p251-258.
ABSTRACT
Calculations of water vapour flow through walls and ceilings are frequently based on the permeability of building materials and implicitly assume that most of the vapour transport takes place by diffusion. Finds that this model is generally invalid since for normal construction practices in U.S. wood frame houses, vapour transport is almost entirely by air movement. "Kraft" paper "vapour barriers" frequently attached to batt insulation do not effectively hinder air or moisture flow into attics. An effective vapour barrier should aim to block air flow and in new housing, a continuous sheet placed between the ceiling and frame of the attic floor should effectively hinder air and moisture flow. Recommends that in existing housing adequate opening for ventilation with outside air to the attic should be provided to prevent moisture buildup and condensation.
KEYWORDS
vapour barrier, attic, condensation, water vapour, moisture,
NOTES
This paper is an updated version of "The effect of material porosity on air infiltration" Princeton project note 3 1977.

#NO 127 Critical significance of attics and basements in the energy balance of twin rivers townhouses
AUTHOR
Beyea J. Dutt G. Woteki T.
BIBINF
Energy and Buildings vol 1 no 3 p261-269 2 figs, 4 tabs, 14 refs. #DATE 01:04:1978 in English BSRIA j.
ABSTRACT
After retrofitting of town houses at Twin Rivers it was found that heat loss from attics was much higher than predicted. This was accounted for by heat transfer within the wall dividing adjacent townhouses (party wall) from each other. This occurs both by conduction and by air movement through vertical holes in the party wall. Suggests that basement is thermally coupled to the attic and adjusts the model to allow for this, giving a three-zone model for the house
KEYWORDS
heat loss, attics,

#NO 377 Moisture in a timber-based flat roof of cold deck construction
AUTHOR
McIntyre I.S.
BIBINF
Building Research Establishment Information Paper. Ip 35/79 #DATE 01:11:1979 in English #AIC 152
ABSTRACT
Reports tests made to examine moisture problems in a flat roof of cold deck construction. Tests simulated the effect of normal, wet and very wet conditions below the roof with no ventilation of the roof. Found that without ventilation there is a substantial risk of moisture degradation and condensation problems. Roof was then ventilated at five air changes per hour and this was found to be effective in solving moisture problems. Suggests this as a minimum ventilation rate and that where it is difficult to provide ventilation in a flat roof, a warm deck design should be considered.
KEYWORDS
roofs, moisture, condensation, ventilation.

#NO 442 Design and performance of roofs.
AUTHOR
Probert S.D. Thirst T.J.
BIBINF
Applied Energy vol 6 no 2. March-April 1980 p79-97 9 figs. 42 refs. #DATE 01:03:1980 in English BSRIA j
ABSTRACT
Surveys factors influencing roof design with respect to energy conservation. Discusses thermal insulation, condensation, ventilation and insolation. Recommendations to prevent condensation in attics include the introduction of a vapour barrier on the warm side of the ceiling structure; provision of a shield in the roof to prevent the ingress of rain that is permeable to water vapour; ventilation of the roof space to the

1

# Ventilation Requirements to Prevent Surface Condensation. Case Study for a Three-Person Dwelling

**Professor V. Meyringer**
**Dornier System GmbH, Friedrichshafen, Federal Republic of Germany**

## Background

While the choice of reduction of transmission losses of a building to very low values is more or less only a question of economics, minimizing ventilation to reduce the heat loss may produce a lot of problems regarding air quality and building physics. This problem has not only been experienced in a great number of buildings in Germany, but it is also a problem common to all IEA member countries.

Ventilation in buildings is required for a number of reasons. These include the need to:

- substitute oxygen consumed by people and flueless fireplaces
- supply combustion air to open-flued combustion appliances
- remove water vapour produced by washing and cooking activities, by people and plants
- remove hazardous pollutants originating from building materials, furnishings, tobacco smoke and the countless household chemicals in use today
- remove odours.

In practice it seems appropriate to consider ventilation requirements under three separate risk aspects. These are:

1. Removal of pollutants harmful to health.
2. Avoiding building damage by moisture.
3. Safe operation of stoves and fireplaces.

Ventilation should be provided in such a way and to such an extent that all three requirements are met. This paper deals with the second aspect, namely that of moisture.

## Ventilation efficiency

Ventilation is an extremely complex phenomenon. With an open window for instance, variations in wind and outside temperature have a strong influence on the rate of air change. But even setting aside such variations, an open window will neither provide for complete mixing of room air, nor will it provide perfect displacement ventilation thus the ventilation efficiency is uncertain.

Ventilation efficiency expresses the ability of a system at a given volume flow rate to dilute or to remove pollutants from specified zones such as occupied areas or cold surfaces, i.e. ventilation efficiency may be defined as[1]:

$$e = \frac{Cx - Co}{CRi - Co}$$

where Cx = pollution concentration in the exhaust air

Co = pollution concentration in the supply (outside) air

CRi = pollution concentration in the room air at location i.

When Cx = CRi, complete mixing occurs, i.e. e = 1 (dilution ventilation). Such a condition may hardly be found in practice but is most commonly assumed for calculation and modelling purposes. The main reason for using this assumption is to account for the complex pattern of air movement in a room.

If not otherwise specified, the air change rate in this paper refers to complete mixing. In many practical cases, special provisions, e.g. range hoods, or users' behaviour, e.g. opening of windows close to the pollution source, will improve vapour removal ($e > 1$); in some other cases it may reduce it, e.g. in 'dead' corners of a room, $e < 1$. In general, however, the air exchange rate referred to by complete mixing is a good average estimation and may, in most cases, be assumed to be on the safe side of the real ventilation efficiency.

Relevant to surface condensation is the dew point of the air in the vicinity of cold surfaces, *not* the average water content of the room air. This is a point of particular relevance for the planning and installation of efficient ventilation systems.

## Production rates of water vapour in dwellings

In contrast to the situation with chemical pollutants, the potential emission sources of water vapour are known. Even though users' behaviour varies in a broad band, the expected range can be estimated.

The following 'model dwelling' will be investigated:

apartment
100 $m^2$ living area
three person family
average factor of presence: 0.7

A number of publications[2,3,4,5,6] specify vapour production rates of sources commonly found in dwellings. Table 1 lists the main sources and their emission rates.

| | |
|---|---|
| Person asleep | 40 g/h |
| Person average activity | 90 g/h |
| Potted plant, average size | 10 g/h |
| Cooking and wet cleaning | 1,000 g/h |
| Taking shower | 2,600 g/h |
| Washing machine | 300 g/cycle |
| Free water surfaces | 200 $g/hm^2$ |

*Table 1. Sources of Water Vapour in Dwellings*

By using these rates in conjunction with the data of the model dwelling, a vapour load as specified in Table 2 results. The total moisture generation rate is about 12 kg per day or, on average, 500g per hour.

As already mentioned, the amount of water vapour actually remaining in the air can be expected to be considerably lower than the values listed because part of the vapour generated by particularly critical processes, e.g. cooking, showers, is normally removed by direct ventilation before mixing with the room air. Additional loads would be added if washing were to be dried in the rooms. However, such drying cannot be considered usual and is normally prohibited by contract. Also, because of the water storage capability of building materials, peak loads of vapour do not generally pose a problem.

| | |
|---|---|
| 24 person hours asleep | 960 g/d |
| 27 person hours average activity | 2,430 g/d |
| 15 potted plants | 3,600 g/d |
| 3 hours cooking/wet cleaning | 3,000 g/d |
| 5 cycles washing machine | 150 g/d |
| 15 minutes shower | 650 g/d |
| 1,000 $cm^2$ free water surfaces | 480 g/d |
| Additional contributions (rain-wet cloth . . .) | 200 g/d |
| TOTAL | 11,470 g/d |

*Table 2. Water Vapour Production in a 3-Person Dwelling*

## Critical building surfaces

The cold outer surfaces of a building are the critical ones producing condensation problems. Gertis[5] has investigated the thermal behaviour of particularly critical building geometries. In a three-dimensional corner in the outside walls of a building under a flat roof ceiling (one of the geometries bearing the highest condensation risk), constructed according to the German building standards of 1981, it was found that the surface temperature will fall below the room temperature by about one third of the difference between room temperature and outside temperature. If, for example, the outside temperature is 2°C and the inside temperature is 20°C, a corner temperature of only 14°C will result. According to the same source, the temperature drop in one-dimensional corners of older buildings (flat roofs are seldom encountered with them) is of the same order.

## Minimum ventilation rate for dehumidification

From the point-of-view of avoiding surface condensation, the ventilation requirement is given by:

> the air change rate that results in the vapour content of the room air in the vicinity of cold surfaces being such that the dew point temperature is below the lowest surface temperature.

Examples of some calculations of minimum ventilation rates to avoid condensation for some typical meteorological situations are given in Table 3. The results presented are for:

- a cold winter day
- an average winter day
- a typical spring or autumn day
- a day on which the outside temperature is just above that at which space heating is required.

In all cases, relative humidity of the outside air is assumed to be 80%, since this value is not exceeded under average German meteorological conditions. The surface temperatures according to Gertis[5] are used for determination of the maximum allowed water content of the room air. As can be seen from the fifth row of Table 3, the maximum admissible humidity is lower during colder days, because of the lower building surface temperature then. Taking into account the vapour production in the dwelling, the necessary air exchange rate can be determined.

It is seen from Table 3 that, for all temperatures during the heating season, an air exchange rate of $\dot{V}_{min} = 85\ m^3/h$ is sufficient in the model dwelling, corresponding to 0.34 air changes per hour. Even in a considerably smaller dwelling of, for example, 70 $m^2$ living area and with the same vapour load, the generally recommended air change rate of 0.5 ach can be considered sufficient. Generally, the use of volume flow rates (e.g. $m^3/h$) rather than air change rates referred to the dwelling's volume (1/h) should be used when specifying dehumidification requirements.

| | Symbol | Cold winter day | Average winter day | Transitional season | Day at heating limit |
|---|---|---|---|---|---|
| Outside temp. | To | –4°C | 5°C | 11°C | 14°C |
| Relative humidity of outside air | $\varphi o$ | 80% | 80% | 80% | 80% |
| Room temp. | Tr | 20°C | 20°C | 20°C | 20°C |
| Temp. at critical building surfaces[5] | Ts | 12°C | 15°C | 17°C | 18°C |
| Admissible room air humidity so that no condensation takes place at Ts | $\varphi adm$ | 60% | 73% | 82% | 88% |
| Vapour absorption capacity of the outside air after being heated to Tr | $\Delta x$ | 6.5 g/kg | 6.4 g/kg | 5.6 g/kg | 4.9 g/k |
| Daily vapour production in the 3-person dwelling | $\dot{m}_{H20}$ | 12 kg/d | 12 kg/d | 12 kg/d | 12 kg/d |
| Minimum ventilation rate for dehumidification | $\dot{V}min$ | 64 $m^3/h$ | 65 $m^3/h$ | 75 $m^3/h$ | 85 $m^3/h$ |

*Table 3. Dehumidification by Ventilation in a 3-Person dwelling*

With rising outside temperature, the minimum required air change also rises. It is therefore important to increase ventilation beyond the specified value *outside* the heating season. This is less of a problem with regard to economy or comfort because no energy losses are taking place and because draught effects play only a minor role during the warm season. However, deliberate measures to increase ventilation are necessary since the thermal forces driving ventilation are weak or absent. Experience shows that these are the conditions at which condensation problems are encountered, particularly during the transitional season. However, there is no public awareness of this problem.

## Discussion of the results

The case presented can be expected to be representative for a great number of dwellings in the existing building stock. In new buildings with improved insulation, which conform to the latest regulations, lower air change rates during the colder season only are permissible. At higher outside temperatures, during the particularly critical transitional period, differences between ventilation requirements for old and new buildings are negligible.

That the specified air change rate is indeed sufficient under normal conditions is confirmed by the observation that in many dwellings air change rates under 0.5 are taking place. Nevertheless, condensation problems occur only then if additional stress factors deteriorate the situation such as:

- additional vapour generation, e.g. drying of washing in dwellings
- use of air humidifiers
- considerable reduction of room temperature, e.g. in bedrooms
- deterioration of the heat transfer coefficient from the room air to critical (cold) building surfaces, e.g. furniture positioned against outside walls
- hydraulic isolation of wet rooms from the remainder of the dwelling (closed windows and internal doors).

It should be noticed that this paper considers only surface condensation. With building envelopes of deficient construction, e.g. vapour barrier wrongly placed condensation may occur inside a building element thereby impairing its function and durability.

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# French and German Translations of AIC Technical Notes

The following technical notes are now available in French and German editions:

**AIC Technical Note 10**
'Techniques and instrumentation for the measurement of air infiltration in buildings – a brief review and annotated bibliography'

**AIC Technical Note 14**
'A review of building airtightness and ventilation standards'

Copies are available, price 15 Swiss francs, from:

Dr. P. Hartmann
EMPA
Section 176
Überlandstrasse
CH-8600 Dübendorf
Switzerland

# An Energy Efficient Ventilation Method for a Kindergarten

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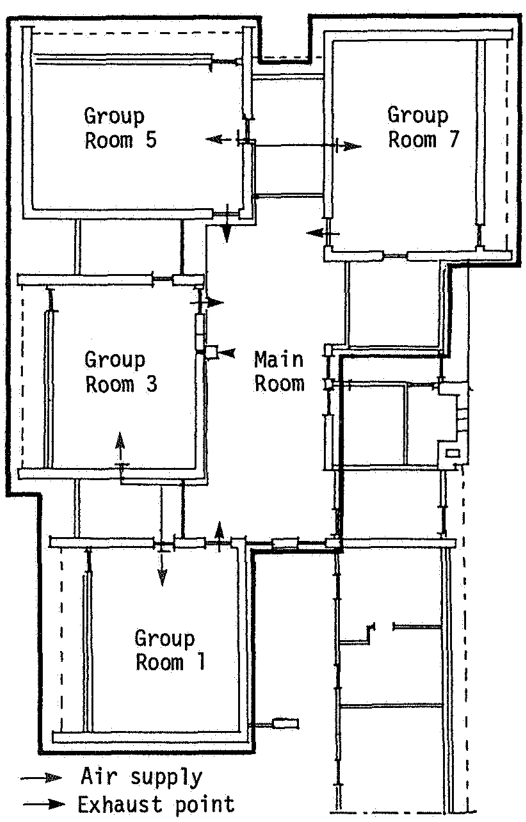
**Technological Institute, Tastrup, Denmark**

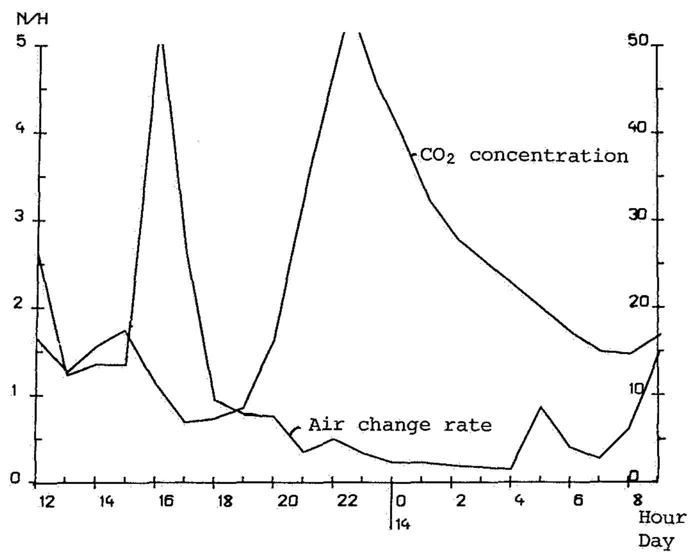
In the last edition of Air Infiltration Review*, we presented our constant concentration tracer gas instrumentation (which actually was the first constant concentration instrument to be used in occupied buildings). We developed this instrument mostly to solve problems of indoor climate in existing buildings and to review the ventilation strategies in the retrofitting of old buildings and in the planning of new buildings.

We are presently working on problems associated with kindergartens which, with regard to indoor climate, are quite overpopulated. Typically, the kindergartens are around 300 m$^2$ in area and 700–1,000 m$^3$ in volume, with 60–80 children, and with natural ventilation only. The basic air change rate is 0.2–0.4 ach. As we have shown*, users have a tremendous impact on air infiltration which, in the kindergartens, rises from the basic 0.2–0.4 to 0.7–1.5 ach when the kindergarten is in use.

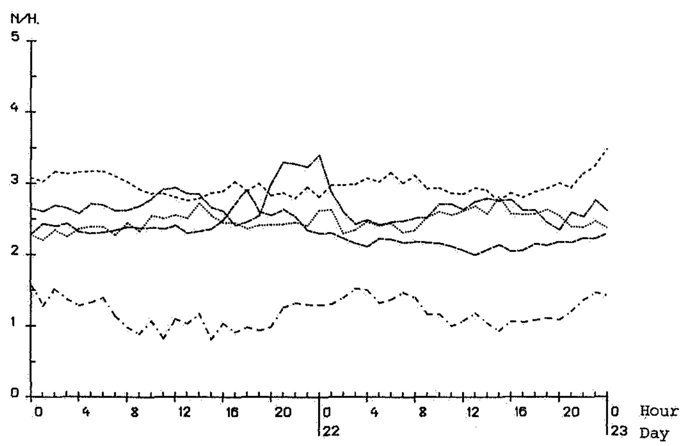
With a 100 day outdoor temperature profile averaging 0°C and temperatures easily going down to −10°C to −20°C, it is impossible to achieve the necessary air change rate of 1.5–2.5 ach in these periods without installing some sort of mechanical ventilation system. In a kindergarten, the normal retrofitting of a mechanical ventilation system with a capacity of 2–3 ach will cost an average of £15–20,000. This generally exceeds the amount of money the local authorities can afford and therefore we have looked at a different approach to the problem.




As shown in Figure 1, we aim to have the air supply inlet in the group rooms (1, 3, 5 and 7) and the exhaust in the main room (9). The philosophy is that the children would be in either the group room using the fresh air there or in the main room using the fresh air coming from the group room not in use. In this way we reduce the ach by 50% without really having any drawbacks, as well as reducing the noise levels and size of ventilation equipment. Thus the cost is reduced to around £4,000 or to 20–30% of the cost of the normal system.




In Figure 2 we have shown a typical output of a measurement of ach and $CO_2$ concentration in an occupied kindergarten with natural ventilation.




| | Measured | | Nominal | |
|---|---|---|---|---|
| Room 9 | (180) | 1000 m$^3$/h | 1000 m$^3$/h | exhaust |
| Room 7 | 280 | m$^3$/h | 250 m$^3$/h | inlet |
| Room 5 | 250 | m$^3$/h | 250 m$^3$/h | inlet |
| Room 3 | 250 | m$^3$/h | 250 m$^3$/h | inlet |
| Room 1 | 220 | m$^3$/h | 250 m$^3$/h | inlet |

Figure 3 shows the measured ach resulting from the application of the new concept.

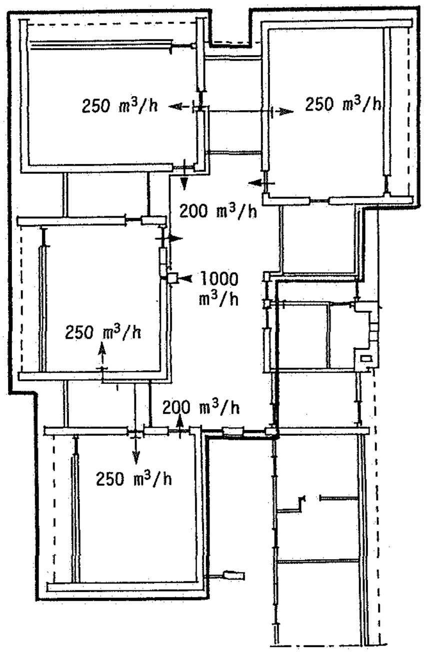
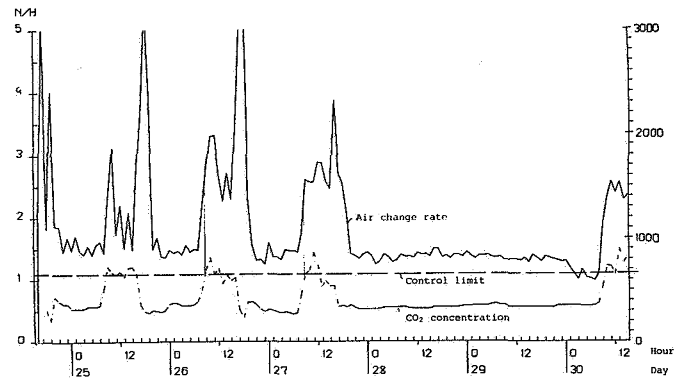



Figure 4 shows the air flow rates through the building. Some of these were measured, others a qualified guess.

Finally, we have installed a $CO_2$ concentration based regulating device for the ventilation system alternating in two steps from one third to full operation. Figure 5 shows the corresponding ach and $CO_2$ concentration recordings.




Future work on this project will be to evaluate the air flow rates, the use of $CO_2$ based regulation and the cost-benefit of the system.

*Air Infiltration Review, Vol. 6, No. 4, August 1985

# IEA Workshop: Condensation Problems – A Search for an International Strategy

**23–25 September 1985**
**Leuven, Belgium**

The executive committee of the IEA Energy Conservation in Building and Community Systems sponsored this recent workshop to discuss surface condensation and mould growth in buildings. This followed widespread concern that remedial measures in existing buildings, aimed at conserving energy demand, as well as poorly designed energy efficient new buildings, were the cause of serious moisture problems in buildings. The objective of the meeting was to explore the reasons for condensation and the growth of mould in buildings, with particular reference to building design, construction methods and occupant behaviour, with a view to devising a plan for joint research. The workshop itself was jointly organised by the Prime Minister's Science Publicity Office, Belgium and the Laboratory of Building Physics of the Catholic University of Leuven.

The meeting began with a series of presentations illustrating the magnitude of the mould growth and condensation problem as it affected the ten IEA countries represented at the workshop. Moisture production by the activities of occupants coupled with inadequately designed means of ventilation and poor thermal integrity of building materials were evident causes of the problem. Possible remedial actions covered improved levels of insulation, the use of extractor fans, increased internal temperatures, dehumidification and the education of occupants.

The papers presented varied from detailed theoretical studies of the occurrence of condensation and mould growth to contributions from those directly concerned with the day-to-day problems of condensation in high risk buildings.

Areas for future research identified at the meeting included the need to:

- develop a reliable hygro-thermal building model from which simplified models could be produced
- carry out measurements for model validation
- investigate the influence of different parameters on moisture balance
- obtain an insight into the potential relationship between energy conservation and moisture in buildings.

A draft strategy for international task-sharing research was prepared for presentation to the IEA executive committee. The items for consideration included:

- a need to analyse the mechanisms of mould growth in detail. In addition, the common species of mould should be identified and their optimum environment for growth determined
- an analysis of existing data relating to both the thermal and the hygroscopic properties of common building materials. Particular needs include thermal conductivity, moisture content of materials (as a function of relative humidity), diffusivity and vapour transfer coefficients

- an analysis of case studies which may be used to verify the performance of mathematical simulation models. The intention is that specific case studies should be analysed using a common format for recording experimental data. The data may then be used to validate appropriate models
- provide information on measurement techniques, especially in the field of non-destructive testing methods. Simple measurement techniques were required, for example, to measure the moisture content of in-situ building elements.

A total of 21 papers were presented at the workshop many of which will be referenced in the AIC database *AIRBASE*. For details regarding the availability of the papers themselves, contact:

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# Book Review

## Energy Use, Infiltration and Indoor Air Quality in Tight, Well-Insulated Residences

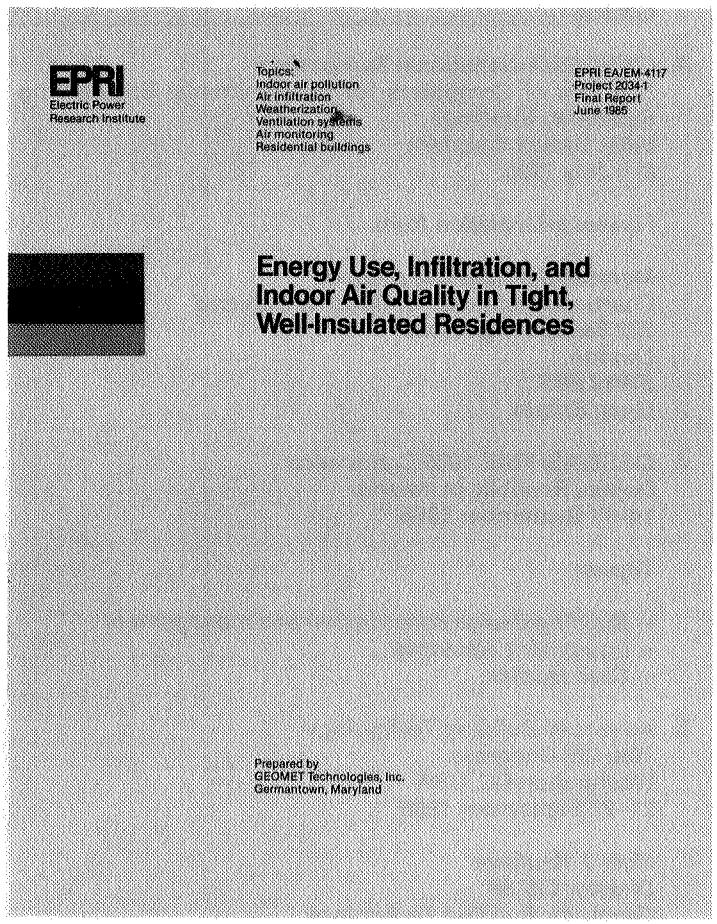
**Prepared by GEOMET Technologies Inc, Germantown, Maryland, USA for the Electric Power Research Institute, Palo Alto, California, USA.**

**Principal investigators: N.L. Nagda, M.D. Koontz, H.E. Rector**

The rate of air infiltration into buildings affects both energy consumption and indoor air quality. In this study, two unoccupied bi-level houses of identical design and construction located on adjacent plots in Maryland, USA were used to investigate experimentally and analytically the relationships among air exchange, energy consumption and indoor pollutants. Mathematical models were developed to describe these relationships.

Obviously the results obtained cannot be generalised without taking into account occupancy effects and conducting similar studies for other housing styles and geographical locations. However, they do provide a comprehensive foundation of data obtained in a controlled manner and giving a greater understanding of the baseline conditions.

The houses were initially monitored for several weeks to assess their degree of similarity, before one was retrofitted and an air-to-air heat exchanger installed. Both houses were then monitored continuously during the summer and autumn of 1983 and during the 1983–84 winter heating season. Parameters measured included air exchange rates and building tightness, electricity used for space conditioning, indoor and outdoor pollutant concentrations including carbon monoxide, nitrogen dioxide, formaldehyde, inhalable particles, radon gas and radon daughters, indoor temperatures and outdoor weather conditions.




Although the houses were unoccupied, some occupant activities that might influence air exchange, energy use or indoor air quality were simulated.

Measurement techniques and results are presented in detail. The results illustrate the effects of the season, retrofitting the building, the air-to-air heat exchanger and the use of a circulation fan. The collected data was analysed further in order to verify the effectiveness of the EMPS 2.0 building energy model for energy use and of models for air exchange and indoor air quality. The energy model explained approximately 95% of the daily energy use variations in the control house in summer and winter and in the test house with the heat exchanger in operation in winter. The air pollution models explained up to 90% of the hourly variations in the pollutant concentrations monitored.

Requests for copies of this report should be directed to:

Research Reports Center (RRC)
Box 50490
Palo Alto
CA 94303
USA
Tel: (415) 965 4081

# Forthcoming Conferences

1. IAQ '86
Managing Indoor Air for Health and Energy Conservation
Atlanta, Georgia, USA
20–23 April 1986

This *ASHRAE* conference is expected to be the premier international conference on indoor air quality in 1986. The gathering will provide engineers, designers, architects and environmental physiologists with the most current information regarding research and practices in what may well be the environmental issue of the next decade.

*Further information from:*

*J.R. Wright*
*ASHRAE Director of Technology*
*1791 Tullie Circle NE*
*Atlanta*
*GA 30329*
*USA*

2. International Symposium on 'Energy and Building Envelope'
Thessaloniki, Greece
22–25 April 1986

*Further information from:*

*International Symposium: Energy and Building Envelope*
*Laboratory for Building and Construction Physics*
*Dept. of Civil Engineering Secretariat*
*Aristotle University*
*546 36 Thessaloniki*
*Greece*

3. CIBSE 5th International Symposium
The Use of Computers for Environmental Engineering Related to Buildings
Bath, United Kingdom
6–9 July 1986

*Further information from:*

*Member Services Department*
*Chartered Institution of Building Services*
*222 Balham High Road*
*London*
*SW12 9BS*
*Great Britain*

4. CIBSE/ASHRAE 1986 Conference
Dublin, Republic of Ireland
14–17 September 1986

*Topics:*

- *Building design construction and management*
- *Equipment advances*
- *Case studies*

5. Advanced Building Technology
10th CIB Congress
Washington DC, USA
21–26 September 1986

*Noël J. Raufaste*
*Director CIB.86*
*Center for Building Technology*
*National Bureau of Standards*
*Gaithersburg*
*MD 20899*
*USA*

6. 7th AIC Conference
Occupant interaction with ventilation systems
England
29 September – 3 October 1986

*See separate Call for Papers. Further details from:*

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*Old Bracknell Lane West*
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7. Indoor Air '87
Berlin (West), Germany
17–21 August 1987

*Further information from:*

*Conference Secretariat*
*Indoor Air '87*
*c/o CPO Hanser Service GmbH*
*Schaumburgallee 12*
*D–1000 Berlin 19*
*Germany*
*Tel: (030) 305 31 31*
*Telex: 186 11 cpo d*

8. ICBEM '87
Third International Congress on Building Energy Management
Lausanne, Switzerland
28 September – 2 October 1987

*Call for papers:*

*Building energy management is a fast growing and rapidly changing field of considerable scientific, technical as well as economic and social importance. The aim of ICBEM '87 is to present the state-of-the-art together with ongoing research in selected fields such as*

- *ventilation, air movement in buildings, air quality*
- *control and regulation of heating and ventilation*
- *field measurement and auditing*
- *building planning process and design tools*
- *energy strategies and the occupants*
- *solar energy use*
- *daylighting and artificial lighting*
- *building concepts for hot climates*
- *building regulatory process*
- *case studies on the above listed topics*

*Preliminary abstracts should be about 200 words in length and typed in English. The abstracts must be received by the Program Committee not later than 1 June 1986.*

*Persons wishing to submit a paper are invited to indicate a preliminary title on the attached form and return it to:*

*ICBEM '87 Secretariat*
*p.a. Prof. Andre P. Faist*
*EPFL – LESO Building*
*CH 1015 Lausanne*
*Switzerland*
*Tel: 021 47 11 11*
*Telex: 24478*

*3rd fold (insert in Flap A)*

*1st fold*

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*2nd fold (Flap A)*

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