Air Infiltration Review
a quarterly newsletter from the IEA Air Infiltration Centre

Vol. 6, No. 3, May 1985

Research Report from Germany

Review of Some Research Issues Related to Ventilation of Dwellings in Germany

Dr.-Ing V. Meyringer
Dornier System GmbH, Friedrichshafen,
Federal Republic of Germany

Introduction

As a result of the oil crisis in 1973, a great number of investigations and research projects were established in Germany and new regulations set up to help reduce energy consumption in the building sector. It was soon recognised that ventilation losses in dwellings constitute a major part of the heating energy losses in buildings and amount to approximately 6% of Germany's national energy demand – not much less than the energy consumption of all private cars in this country.

Consequently, the investigation programme 'Ventilation in residential buildings' (Lüftung im Wohnungsbau) was begun in 1978. The programme was sponsored by the Federal Ministry for Research and Technology in conjunction with the Federal Ministry for Regional Planning, Building and Urban Development. Its main activities started in 1980.

Even though the basic aim of the programme was to identify possibilities for reducing ventilation heat loss, it was also considered necessary to deal with many other questions which were only indirectly concerned with energy savings. From the beginning therefore, studies of air hygiene, air requirements and emissions from fireplaces, as well as occupant behaviour were included in the programme which thus became an interdisciplinary venture. In the meantime, the focus of public attention has moved from energy conservation to the question of indoor air quality. This move was caused not only by released tensions on the international oil market but also by a growing concern about pollution both inside and outside dwellings.

This article outlines the research programme and discusses selected topics in greater detail. Although all the projects refer to the results of studies in Germany, they should be of relevance to many other countries too.

General review of research programme

The programme is divided into three overlapping phases:

Phase I: Basic studies

- room air pollutants, minimum ventilation rates
- impact of operation of stoves on room air quality
- standard procedures for measurement of air-to-air heat exchangers
- comparison of different ventilation systems in uninhabited experimental houses

Phase II: Studies on inhabited houses

- investigations on five inhabited houses with and without ventilation systems and covering inhabitant behaviour, air change rates, air quality, energy consumption, noise level, operational experience.

Phase III: Analysis and evaluation of results

- analysis of natural ventilation systems
- analysis of mechanical ventilation systems
- requirements of buildings, equipment and users if ventilation systems are to be effective.
- comprehensive summary of programme

Phase III is essentially complete with most projects now terminated and reports either published or in the finishing stage except for the comprehensive summary.

An important aspect of the programme is its connection with the International Energy Agency (IEA) within the programme 'Energy conservation in buildings and community systems'. The Federal Republic of Germany is a member of Annex VIII 'Inhabitant behaviour' and of the Air Infiltration Centre (Annex V) and is leading the work of Annex IX 'Minimum ventilation rates'. IEA activities will continue even after the termination of Phase III of the programme.

Some essential results of the programme are summarised within the following ten points.

1. The problem of ventilation in residential buildings is rather complex and involves various branches of technology and industry from building design through construction material production to heating and ventilation systems design. In addition, the co-operation of hygienists and physiologists (cause and effect of harmful substances) is required. Emphasis must be on integrated rather than individual effort.

2. It was discovered that the approach of residents to ventilation is only slightly characterised by objective requirements and is instead marked strongly by individual habits and by subjective feelings. Extremes at both ends of the spectrum (no ventilation or continuous ventilation) are by no means exceptions. Even in houses with a ventilation system fitted, the possible savings in energy are mostly negated by the attitude of the residents, who were generally not sufficiently informed and therefore also not motivated. Therefore, intelligent window ventilation habits cannot be expected of the average inhabitant.

3. Precise and generally valid figures cannot be given for the necessary air change rate since this depends on parameters such as emissions from building materials, air flow pattern and how frequently and in which way rooms are used. However, an average air change rate of 0.5 per hour (in relation to the total volume of the dwelling) should comply with all normal requirements, although zones requiring more intensive or less intensive ventilation may exist for a time during the course of the day (depending on the amount and kind of use). Total ventilation required still remains within the described order. Elimination of excessive pollutant emissions from building materials, cleaning agents, etc. should be considered a problem of the producer and not be transferred to ventilation.

4. With natural ventilation (window ventilation) control is extremely difficult and permanent attendance is required to maintain adequate room air quality whilst avoiding waste of energy. Depending on the effect of fluctuations in wind speed, wind direction and temperature, a variation range of 1 to 20 or more can be achieved easily with the same window position.

5. As a consequence of conservation measures, airtight buildings pose a major safety risk to dwellings with open fireplaces or stoves, if no separate provisions are made for supply air.

6. Considered from both the viewpoint of energy and hygiene, mechanical fan ventilation offers the best solution. If properly designed, it ensures freedom from the influence of wind and temperature, provides the necessary air change at all times and, with only a small amount of electricity needed, permits, with an airtight house, the reclamation of more than half the heat lost by ventilation.

7. Nearly all the ventilation systems investigated have shortcomings, some more serious than others. Typical problems include:
   - unacceptable noise level
   - severe draught effects
   - high auxiliary energy consumption
   - design flow rates not established
   - odour transmission from bath/kitchen to living rooms
   - deficient installation (no acceptance test performed)
   - no maintenance provisions

8. The importance of residents' acceptance of ventilation systems cannot be overemphasised. Systems must be designed for user comfort and ease of maintenance.

9. Present ventilation techniques for dwellings based on the principle of contamination dilution are rejected by many users because of inherent noise and draught. Instead, 'soft' displacement ventilation techniques which take advantage of natural buoyancy forces can be expected to provide major improvements in ventilation efficiency and user comfort in the future.

10. The design and construction of ventilation equipment currently in use and on the market offers plenty of opportunity for functional improvement and more cost effective production and installation, indeed this improvement must be considered a prerequisite for market penetration.

Natural ventilation

In Germany, natural ventilation (through infiltration and windows but seldom airbricks) is still the dominant method of controlling indoor air quality in dwellings. The only ventilation device commonly encountered is the range hood above the kitchen stove which has no air change effect at all if it is only recirculating poorly filtered air, as is mostly the case. Only a small percentage of all dwellings have stack ventilation or exhaust ventilation, but only for windowless rooms. The number of central systems serving the whole dwelling is negligible. It was therefore considered necessary to evaluate the efficiency and controllability of windows and adjustable ventilation openings (using wind speed, wind direction, temperature difference ($\triangle T$) and opening width as parameters).

A test room was used, about the size of a small living room, with provisions to fit the ventilation devices under test. Tracer gas was used to determine the air change rate (decay method). Wind speed, wind direction, inside/outside temperature and pressure differences were measured.

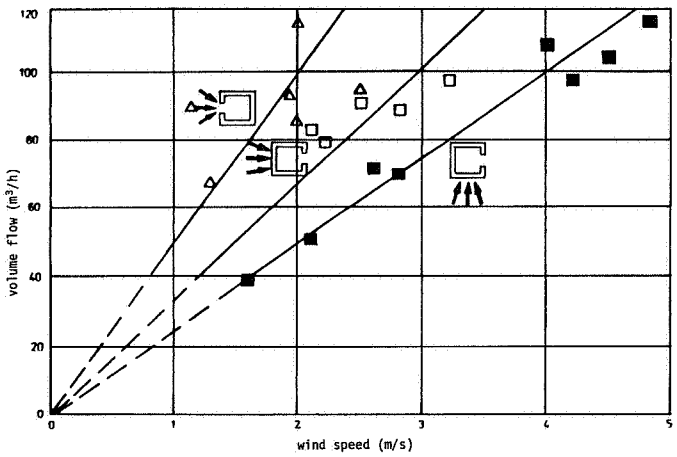


Figure 1: Volume flow through tilted window as function of wind speed and wind direction

Congruent with theory, it was found that (most commonly during the heating season) the volume flow through a tilted single window in an airtight house was linearly dependent on the width of the gap and on wind speed (see Figure 1). Wind direction provides an additional variation range of about 1:2. Cross ventilation with two windows increases the wind induced volume flow by a factor of 5 to 10. By contrast, dependence of volume flow on inside/outside temperature difference (with no wind) follows a square root law (see Figure 2).

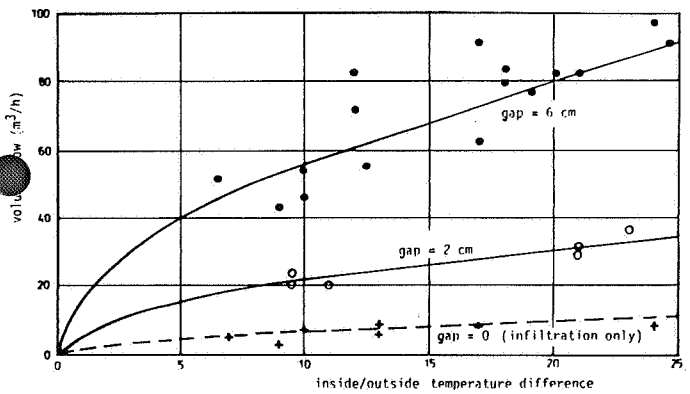


Figure 2: Volume flow through tilted windows as function of ΔT

If both temperature difference and wind are taken into consideration, as is generally the case, no linear superposition is allowed. In some cases even a reduction of the flow volume may result. As a rule of thumb it may be assumed that, for a single open window, wind effects are dominant for wind speeds above 2 m/s, while for wind speeds below 2 m/s and ΔT above 10K, temperature effects play the major part. Figure 3 shows the range of flow volume for a tilted and for a hinged window in three opening positions and with parameter variations as follows:

V = 0 to 6 m/s

ΔT = 0 to 30 K

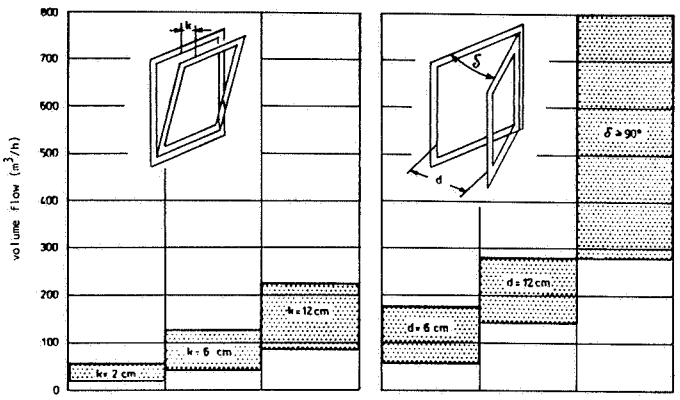


Figure 3: Volume flow range of open windows ($v = 0-6$ m/s, $\Delta T = 0-30$K)

For controllable ventilation openings, basically the same characteristics apply with regard to wind and temperature influence as for windows. To obtain any perceptible ventilation effect without wind in tight buildings, complementary openings must be fitted as far apart vertically as possible (ideally at floor and ceiling level) to utilize thermal buoyancy effects as driving forces. Figure 4 shows some types of ventilation openings controllable by sliding elements. Most ventilation openings are integrated into windows and some are equipped with acoustic dampers.

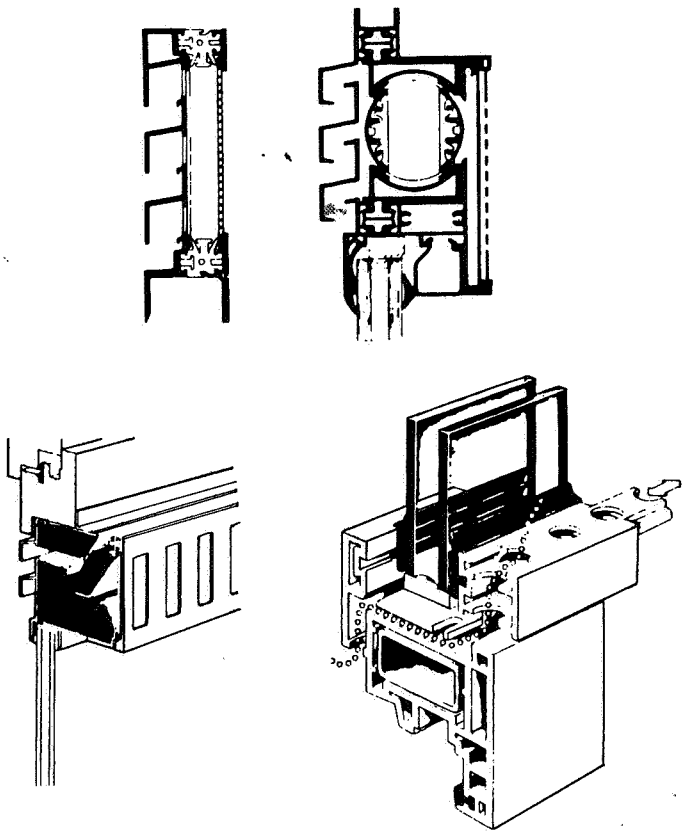


Figure 4: Some types of controllable ventilation devices

One of the shortcomings of typical natural ventilation devices is poor control characteristics (see Figure 5). Whilst a slightly progressive characteristic would be most desirable (case 3), most devices were found to be degressive (case 2). The effective area of the air vents investigated was found to be too small to provide sufficient ventilation. Typical air flow rate of a single device (A = 104 cm^2) without wind was negligible, with two vents at 1.3 m vertical distance and ΔT = 10K it was about 15 m^3/h.

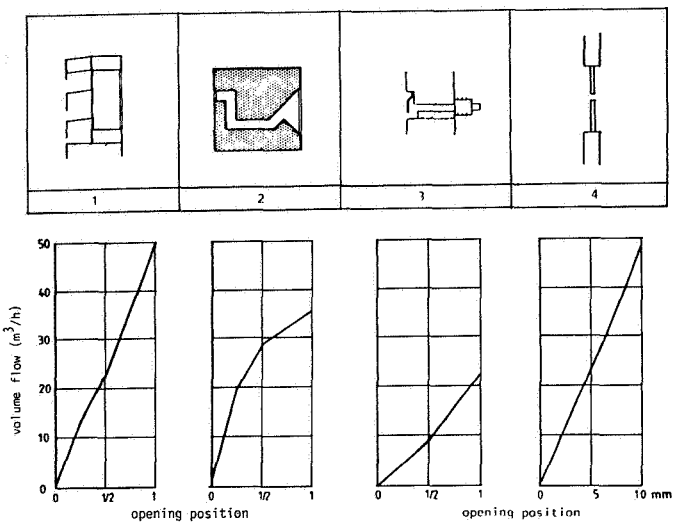


Figure 5: Control characteristics of various ventilation devices

Though it can be concluded that natural ventilation is extremely difficult to control, there are some options for improving the efficiency and handling of such systems, e.g:

- window fittings should allow locking of windows in progressively adjustable narrow-gap positions
- cross section of ventilation openings should be increased considerably
- control characteristics of air vents should be improved
- air vents should be used only in pairs and vertically spaced.

Fireplaces and stoves in airtight buildings

Airtight building envelopes pose a major indoor air quality risk for dwellings equipped with open fireplaces or stoves. To evaluate the general situation in Germany, a project within the Ventilation Programme was designed to assess:

- average and minimum expected infiltration rates in the existing building stock in Germany
- contamination of room air (because stoves depend on indoor air for combustion) as a function of reduced air flow rates

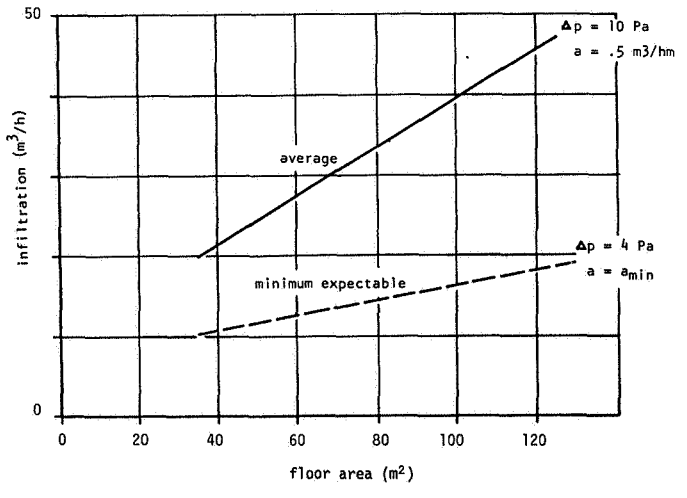


Figure 6: Infiltration rate of dwellings constructed between 1950 and 1980

Since the aim of the project was a risk analysis, emphasis is on the minimum acceptable infiltration. It was found that this minimum is determined by window joints, roller blinds, main door and building element joints. Infiltration through walls or ceilings of brickwork or concrete was found to be negligible and, contrary to general opinion, ageing effects of window sealing strips had no significance. Figure 6 shows infiltration rates for buildings constructed between 1950 and 1980, the dotted curve giving minimum acceptable rates (low leakage coefficients, low outside/inside pressure difference) and the continuous line the average rates. In Figure 7 hourly air changes are shown for the same cases. It can be seen that excessively low rates below 0.1 air changes per hour or 15 m^3/h can be expected if no window ventilation is used. This is a health risk even without stoves in operation.

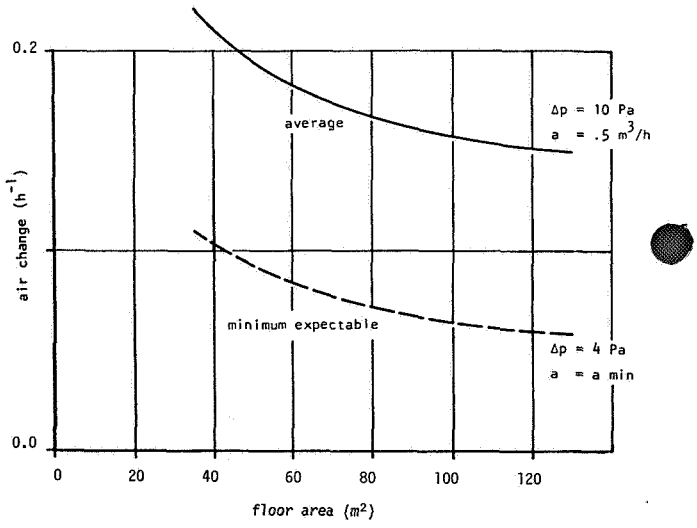


Figure 7: Air change rates of dwellings constructed between 1950 and 1980 (infiltration only)

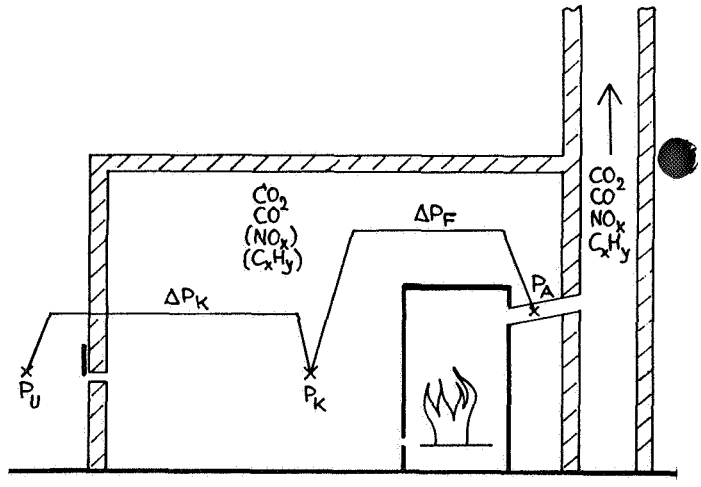


Figure 8: Pressure distribution in test room

To evaluate the operation of stoves under variable conditions, an airtight test room was established with provision for the control of the air flow rate from the exterior into the room and to control pressure P_A in the flue pipe, thus influencing $\triangle P_F$ (see Figure 8). Composition of the flue gases was measured, as well as contamination of the room air by flue gas leakages under varying operating conditions. Decisive for the safe operation of stoves is the differential head between room interior and flue pipe ($\triangle P_F$). Various stoves, e.g. solid fuel (wood, coal), liquid fuel (oil) and gaseous fuel (natural gas) have been investigated.

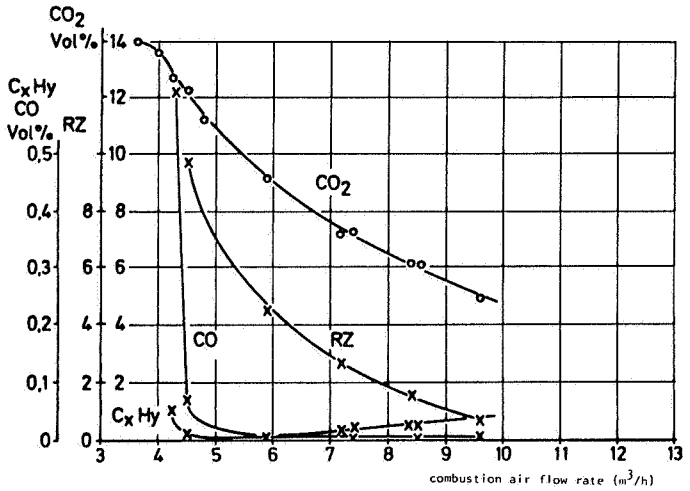


Figure 9: Flue gas composition as function of air flow rate with oil stove under partial load

As an example, Figure 9 shows combustion product concentrations in the flue gas for an oil stove under partial load condition. By contrast, Figure 10 displays room air contamination with CO through a coal stove operating with various differential heads.

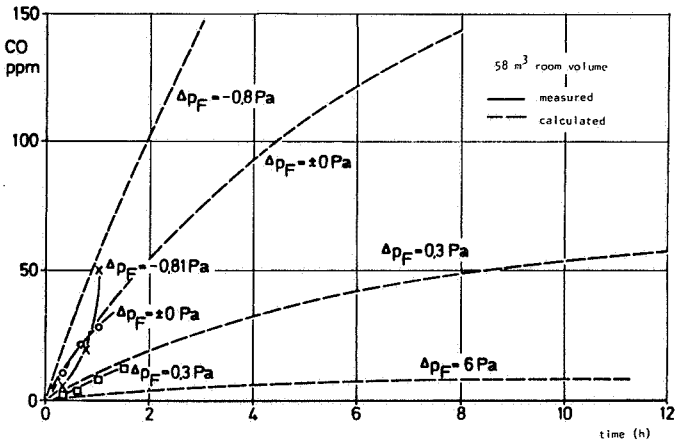


Figure 10: Room air congestion through coal stove for various differential heads

Stoves for solid fuel were found to be self-regulating, i.e. their heating power was governed to a certain degree by varying air flow rates and differential heads. Thus room air contamination under unfavourable conditions was less severe than with oil or gas stoves. It also appeared that emission of flue gases into the room would be reduced by improved/modified construction of most stoves.

Oil stoves have been found to be sensitive to wind influences (with windows or air vents open) as well as to air deficiency (everything closed). This effect was also true of gas stoves, but to a lesser degree, and makes it difficult for them to work properly under all practical conditions.

The only solution to overcome the safety problem for fireplaces and stoves seems to be to provide separate combustion air feeding channels for every unit.

Inhabitants' ventilation behaviour

It was observed that inhabitants' control of ventilation was inadequate. Even in buildings with fitted ventilation systems, no significant changes in attitude have been observed. Figure 11 displays graphically the average ventilation habits of a sample of 230 dwellings during the daytime. Whilst unoccupied bedrooms are ventilated throughout most of the day, kitchens and living rooms in constant use are rather poorly ventilated.

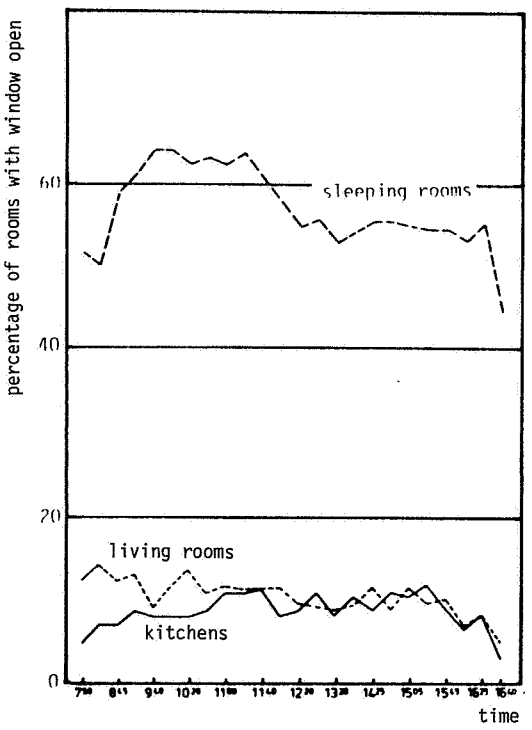


Figure 11: Window ventilation habits

Another more general problem was encountered during the course of these investigations, i.e. the response of inhabitants to inquiries regarding their ventilation habits was definitely unreliable. Figure 12 shows the discrepancy between the estimates of inhabitants and the results of observations. It is therefore highly probable that answers relating to issues other than ventilation are not much more reliable. One must conclude that questions requiring quantitative estimates should be avoided with future inquiries.

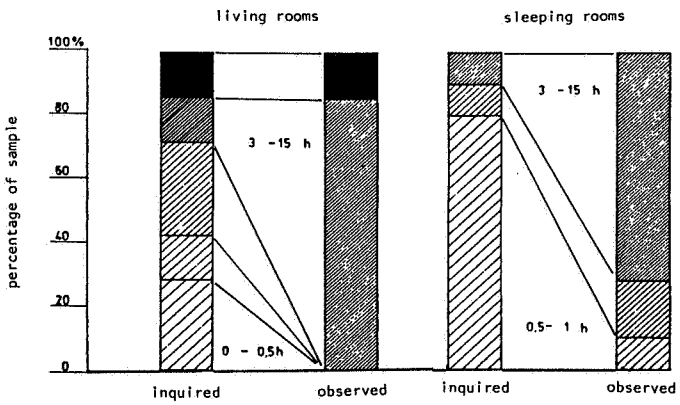


Figure 12: Reliability of inhabitant inquiries regarding duration of window opening

Inhabitants' attitude towards ventilation systems was found to be very conservative to say the least. Causes were not only deficiencies in information and motivation, but must be attributed to a large extent to functional deficiencies of the system itself. Before changes occur in inhabitants' acceptance, considerable improvements in system design and construction must take place.

Requirements for properly designed ventilation systems in dwellings

Complaints about almost every ventilation system have previously been outlined under item 7 in the first section, the most common being draught effects and noise levels. Other shortcomings investigated were comparatively less important. However, these should of course be considered with new systems.

It seems as if conventional (dilution) ventilation systems cannot solve the problem of ventilation requirements. The degree of removal of the polluted air set against the air change rate is low, energy demand and noise level are high and draught effects inherent. The only advantage of dilution ventilation seems to be that it is less susceptible to variations in the ambient conditions of the room interior (due to its forced air circulation pattern) and thus works together with nearly every heating system and tolerates rather wide variations in planning parameters.

More effective 'soft' displacement ventilation systems with much less noise and draught generation are already being used in larger rooms, e.g. conference rooms, theatres, etc. Such systems might be considered a hybrid between natural (buoyancy) ventilation and forced ventilation systems. Displacement ventilation seems to offer a variety of advantages for residential buildings too, where it has not been employed so far.

AIRBASE – the Air Infiltration Centre's Bibliographic Database

Yvette Parfitt, the AIC librarian, describes the Centre's activities in the field of information dissemination and encourages further participation in a valuable international library service.

Introduction

The aims of the Air Infiltration Centre include the cataloguing and transfer of information and full dissemination of current worldwide research in the field of air infiltration. To further these aims, the Centre has established a library of literature, the contents of which are recorded on *AIRBASE,* a computerized bibliographic database. Many of the initial references were drawn from the extensive resources of the library of the Building Services Research and Information Association. Since then it has been continuously updated as new articles are received by the AIC's library. There are presently more than 1,700 references in the database and it is growing at the rate of some 20–30 articles per month. Sources include periodical articles, conference papers, unpublished research papers, books and so on, mainly from the participating countries of the AIC but also from organisations and researchers in other countries active in the field of air infiltration. *AIRBASE* contains articles in over 15 different languages. When an article is considered of particular importance, a translation into English is made and these translations also figure in the AIC database.

Subject Coverage of *AIRBASE*

The main focus of the database is, of course, air infiltration. As such it covers all aspects of the uncontrolled flow of air through cracks and openings in the building envelope, particularly its prediction, measurement and methods for reducing it. Also included are selected papers from the related fields of indoor air quality, occupant behaviour, thermal comfort, ventilation efficiency, natural and mechanical ventilation, wind pressure and its influence on infiltration, and energy saving measures. The principal subjects to be found in the database are:

- tracer gases
- tracer gas measurement by type of building
- tracer gas methods
- pressure tests of leakage of building components
- pressure tests of leakage of buildings
- surface pressures on buildings
- theoretical models of air infiltration and air flow, including comparison of calculated and measured results
- mathematical models
- empirical models
- reduction of heat losses
- energy and buildings
- pollution, air quality and indoor climate
- moisture and humidity
- occupancy effects
- instrumentation and measurement techniques
- the use of heat exchangers
- effects of turbulence

Arrangement of the data in the database

The structure of each database entry follows a common format beginning with a unique *AIRBASE* abstract number, followed by the title of the article. For non-English articles, the title is given in both the original language and in English. The remaining headings are AUTHOR, BIBINF, ABSTRACT and KEYWORDS (see Figure 1).

```
#NO 1570 Multi-chamber air renewal survey using constant concentration
tracer-gas technique.
Mesures du taux de renouvellement d'air a l'aide d'un dispositif
compact a concentration constante.
AUTHOR
Scartezzini J-L., Roecker C., Quevit D.
BIBINF
Groupe de Recherche en Energie Solaire, Ecole Polytechnique Federale
de Lausanne,1984. 13pp, 7 figs, 11 refs. #DATE 00:00:1984 in French
#AIC 973
ABSTRACT
An accurate determination of air renewal rate and connective exchanges
between units was needed for study of the solar units of the
experimental building LESO, in both an occupied and empty state. The
CESAR compact equipment for tracer gas (nitrous oxide) measurement was
developed. This unit uses a microcomputer to perform a simultaneous
and periodical gas analysis in 10 locations. Three tracer gas methods
can be used: decay, constant concentration, and continuous flow. The
device and regulating program work well with low rates of
concentration (100ppm of nitrous oxide). The measurements by decay and
constant concentration give similar results and with the simultaneous
survey of the 10 rooms, a comparison between air movement and
infiltration is possible. Occupancy effects can also be evaluated.
KEYWORDS
air infiltration, tracer gas, nitrous oxide, decay rate, constant
concentration, constant emission, air movement, occupancy effects,
measurement technique, automatic equipment
```

Figure 1: Typical AIRBASE *abstract*

BIBINF furnishes a complete bibliographic description of the item including the name of the publisher or publication from which the document is taken, the date of publication and its language. It also gives other useful information such as the number of graphs, diagrams, tables and references included in the work. The final data given in the BIBINF section is the accession number of the document in the AIC library system. This facilitates location of the original document in response to a request. The ABSTRACT section contains an informative summary in English for every article, no matter what its language of origin, focusing on the relevant aspects of the article from the point of view of air infiltration research.

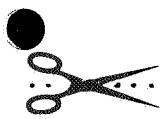
KEYWORDS are taken from a fixed thesaurus of terms which describe the articles in *AIRBASE*. They are used to enhance the description of the document so that it conforms to a set terminology. The abstract reflects the original wording of the document. For example, an abstract mentioning 'climate chambers' in the text would be given the keyword 'environmental chamber', enabling a search under either term to retrieve this document. Occasionally an article does not actually mention the subject by name at all in which case it will only appear in the keyword list, but usually the subject will appear in both places, allowing a search to be done either on the complete article or, for greater speed, just on the KEYWORDS section.

Dissemination of the information contained in *AIRBASE*

AIRBASE exists as a repository of information that can be interrogated on any subject in the field, as the need arises. However this is essentially a passive dissemination of knowledge by user demand. In order to promote use of *AIRBASE* and to actively transfer the information it contains, several printed publications have been introduced which are generally available free-of-charge to researchers and organisations in participating countries.

The first of these is **Recent Additions to *AIRBASE***. This is a quarterly bulletin of abstracts added to *AIRBASE*. It provides an effective means of keeping up-to-date with published material on air infiltration and associated subjects. To ensure the wide dissemination of literature, recent additions will in future be forwarded to all recipients of Air Infiltration Review in participating countries. Copies of the papers abstracted in Recent Additions to *AIRBASE* can usually be obtained from the AIC library by completing the literature request form in the back of each issue. Such items are provided subject to the usual copyright restrictions. Longer documents are available on loan for a one month period.

When enquiries on a particular topic are frequently requested from *AIRBASE,* a **Literature List** is printed on that topic. Lists produced to date are included in the publications list at the end of this newsletter. These contain all abstracts from *AIRBASE* on the given subject, and most have between 10 and 30 abstracts. The complete *AIRBASE* entry for each article is also given.



AIRBASE – REQUEST FORM

Name: _____ Office Use

Address: _____

_____

Subject of search (Please be as specific as possible) _____

_____

_____

_____

Date (I am not interested in papers published before . . .) _____

Language (I am only interested in the following original languages) _____

_____

_____

Finally, an in-depth analysis of the complete database by subject is prepared approximately every two years. The most recent issue is **AIC-TN-15-84 Thompson C. A subject analysis of the AIC's bibliographic database – *AIRBASE*, 3rd edition.** This covers all entries in the database up to #No. 1,276. It is divided into three sections. Section 1 of the report contains the analysis itself, in which articles are listed by reference number under one or more of 14 major subject headings. Each heading is further subdivided to give a total of 175 subject areas. Section 2 contains a listing of author, title and bibliographic details in reference number order, so that the relevant articles on any particular subject can be found. An index of principal authors is given in an appendix.

The contents of *AIRBASE* also form the basis of several **Technical Notes** produced by the Air Infiltration Centre.

Searching *AIRBASE*

AIRBASE is a free language, online bibliographic database available for use by any organisation in the participating countries of the Air Infiltration Centre. It can be accessed on your behalf by the AIC librarian simply by providing her with details of the subject of interest, together with any restriction on the date of publication or language of the articles to be retrieved. Copies of the original documents can then be obtained from the AIC by citing the *AIRBASE* numbers of the articles required. Yvette can be contacted by letter, by telephone on +44 344 53123 (telephone answering machine outside office hours), by telex on 848288 (BSRIAC G) or by using the enquiry form printed above. Every effort will be made to ensure that enquiries receive prompt attention and that replies are despatched as soon as possible.

Some non-UK users may find it more convenient to interrogate the *AIRBASE* database directly online, and they are asked to contact their Steering Group representative for details of the procedures to be followed to access *AIRBASE* using the international telephone system and a modem. Copies of the original documents whose abstracts have been retrieved can then be ordered from the AIC, as above, by citing the *AIRBASE* numbers of the articles required.

Use of *AIRBASE*

AIRBASE was created to aid the transfer and dissemination of research on air infiltration in the member countries of the Air Infiltration Centre. Its use is available completely free-of-charge and it is used by researchers from all the participating countries. In 1984 approximately 2,300 copies of articles and 700 literature lists were sent out in response to requests. In addition several online subject searches were also performed.

AIRBASE provides an efficient means of bringing research to the attention of other people working in the same area and for this reason many of the leading experts in the field regularly send the results of their research to the Air Infiltration Centre for inclusion in *AIRBASE*. It is this direct contact with its users that makes *AIRBASE* so much more effective than other bibliographic databases which simply rely on scanning the published literature. Hopefully, this user involvement will endure as *AIRBASE* continues to expand.

Future Plans

The 4th edition of the subject analysis of *AIRBASE* should be published in early 1986. An extension of the subject coverage is planned, to include more works on ventilation aspects of indoor air quality. The increasing concern related to air infiltration and ventilation stems not only from its energy implications but also from increasing attention to the quality of indoor air.

Within the vast scope of the subject, it will be necessary to restrict the involvement of the AIC to those aspects which are directly related to infiltration and ventilation. This includes criteria for the specification of acceptable indoor air quality, rates of emission of pollutants from commonly used materials, instrumentation for the measurement of pollutant concentration levels, methods of controlling rates of ventilation to maintain acceptable indoor air quality, and statutory regulations concerning air quality. No attempt will be made to cover the chemical, physiological or pathological aspects of the subject. It is a subject that will undoubtedly gain in importance as the industry becomes increasingly sensitive to matters concerning the quality of the environment in buildings.

Ventilation requirements are another subject related to both indoor air quality and air infiltration that is becoming more significant as the emphasis in research broadens from simple energy saving to encompass the implications for human comfort. Recent concern about the overtightening of both naturally and mechanically ventilated buildings is leading to new appraisals of the ventilation rates necessary for modern buildings, taking into account occupancy, air quality and infiltration factors.

Summary

The *AIRBASE* bibliographic database on air infiltration and related subjects has grown from its inception five years ago to become a major source of information on research in the field. Its planned expansion touching on air infiltration research should make it relevant to a greater number of researchers, as well as to people in the industry, without too great a dilution of subject interest.

'Air Infiltration' at *ASHRAE* Winter Meeting

D.T. Grimsrud
Lawrence Berkeley Laboratory, California, USA

The *ASHRAE* winter meeting was held 27–30 January 1985 at the Palmer House in Chicago. Several sessions were held that would interest readers of AIR.

The committee revising *ASHRAE* Standard 62-181 met on Sunday morning, 27 January, to continue its deliberations. Substantial progress was made and it is hoped that a draft version of the revised Standard will be available for public comment by 1 July. Major changes that are likely to emerge in the draft revision include increases in ventilation rate guidelines in the Ventilation Rate Procedure and a softening of the list of target concentrations in the alternate, i.e. the Indoor Air Quality Procedure.

A Symposium 'Residential Air-to-Air Heat Exchangers' was also held on Sunday morning. Papers presented (which are available as reprints from *ASHRAE)* included:

1. 'Outset of Freezing in Residential Air-to-Air Heat Exchangers', R.E. Chant *et al.,* University of Manitoba.

2. 'Performance of Residential Air-to-Air Heat Exchangers during Operation with Freezing and Periodic Defrosts', W.J. Fisk *et al.,* Lawrence Berkeley Laboratory.

3. 'Formaldehyde and Tracer Gas Transfer Between Airstreams in Enthalpy-Type Air-to-Air Exchangers', B.S. Pedersen *et al.,* Lawrence Berkeley Laboratory.

When requesting papers from *ASHRAE,* please specify symposium CH-85-3.

On Monday morning John Janssen of Honeywell chaired a forum entitled, 'Air diffuser performance index vs. ventilation efficiency: are they compatible or not?' A forum is the least formal format for a session at an *ASHRAE* meeting. It begins with a prepared statement from the session chair, and the floor is then open for general discussion. The Air Diffuser Performance Index, or ADPI, is used by ventilation engineers to characterize uniformity of thermal comfort in a room conditioned using air diffusers. The forum provided an opportunity for those who developed and use ADPI to discuss similarities and differences of the ADPI and the concept of ventilation efficiency. Ventilation efficiency, a measure of a ventilation system's ability to remove pollution from a space, is also an index of mixing within the volume. It became clear that those who use either index tended to be unfamiliar with the measurement procedures and results associated with the other. After extended discussion, several of those who attended agreed to pursue the ideas further by assembling a work statement for a research project that *ASHRAE* would sponsor to extend the ideas and make them more accessible for the practicing engineer.

A final session of note at this Conference was the seminar on Wednesday 30 January, 'Tracer gas measurements of ventilation rates in mechanically ventilated buildings'. Seminars differ from sessions of technical papers or symposia because no formal, written papers are published. Seminars are intended to allow a speaker to discuss current work in progress in particular research areas.

This seminar was organized to survey progress in translating tracer gas techniques that had previously been used for residential ventilation measurements to larger commercial buildings containing mechanical ventilation systems. Tracer measurements in this group of buildings have several goals. These include determination of total ventilation rates, the infiltration component of these rates, and the distribution of ventilation air. A parallel goal of this effort is the development of simple, inexpensive measurement techniques so that the procedures can be used widely once perfected.

Four papers were presented at this session. We note that many of these topics will be discussed in a symposium (written papers) devoted to multicell infiltration problems at the Honolulu meeting of *ASHRAE* that will be held in June. The four papers were:

1. 'Application of the Tracer Gas Method to Evaluate Building Air Exchange Rates', D.T. Harrje, Princeton University.

2. 'Commercial and Institutional Building Ventilation Measurements', B.H. Turk, Lawrence Berkeley Laboratory.

3. 'Application of Perfluorocarbon Tracers to Multizone Airflow Measurements in Mechanically and Naturally Ventilated Buildings', R.N. Dietz, Brookhaven National Laboratory.

4. 'Air Infiltration and Ventilation in Office Buildings', A.K. Persily, National Bureau of Standards.

Mr Harrje reviewed various measurement procedures employing tracer gases that had been used in residences. The extension of the container method was discussed in relation to large office buildings having several air handling systems. Measurement results from this example showed ventilation rates three times larger than expected for the buildings.

Mr Turk described measurement results giving total ventilation rates and concentrations of several selected indoor air pollutants in 28 commercial buildings in the Pacific Northwest. Entire buildings were seeded with tracer gas (SF_6); tracer decays were measured in many separate locations. Ventilation values reported were considerably higher than those recommended in Standard 62-81. The dominant pollutant observed in the buildings at this stage of the study has been respirable suspended particles associated with smoking.

Mr Dietz described the use of a constant injection passive sampling system that uses one or several perfluorocarbons as tracers. The application and use of multiple tracers to determine air flow between zones of a simple building and between regions served by different air handlers in a complex structure was discussed.

Mr Persily showed the results of a long-term series of SF_6 tracer decay measurements in nine office buildings located in different regions of the United States. Extended measurement times in each building permitted differences in ventilation rates with changes in weather to be monitored. The conditions of minimum outside air during the coldest and warmest times of the year are observed clearly when measured values were plotted as a function of inside-outside temperature differences. These regions were separated by much larger ventilation rates during times of milder weather conditions. Some of the buildings were operated at times at ventilation rates lower than recommended in Standard 62-18.

Book Review

Occupant behaviour with respect to ventilation – final report 1984

N. Lorimy and C. Vezin
Building Research Institute, Federal Polytechnic, Zurich, Switzerland

This publication is a complementary study to IEA Annex VIII on inhabitant behaviour with respect to ventilation, undertaken at the Institut de Recherche en Matière de Bâtiment, Ecole Polytechnique Fédérale, Zurich. It is presented in two volumes, with the second volume comprising a comprehensive bibliography on occupant behaviour.

The authors begin by suggesting that occupant behaviour at any particular time is conditioned by a variety of differing needs which the occupant seeks to satisfy by modifying his personal environment by any means at his disposal. Looked at from this perspective, occupant behaviour can be analysed by a study of his requirements and of the means available to satisfy these needs in a given environment.

To reduce ventilation heat loss, it is necessary to understand as precisely as possible the reason for occupant ventilating behaviour so that future recommendations will correspond to the occupant's needs and are therefore more likely to be adopted.

The study itself comprises:

- a review of the research on occupant ventilating behaviour
- recommendations for concrete solutions and energy-saving measures in buildings, underlining their advantages and disadvantages
- a survey of the lacuna in our knowledge of occupant needs and of the needs/means interface, with propositions for improving coverage of these areas
- recommendations for more experimental or empirical study of certain outstanding questions
- an annotated bibliography.

The limits within which ventilation heat loss can be reduced are defined by:

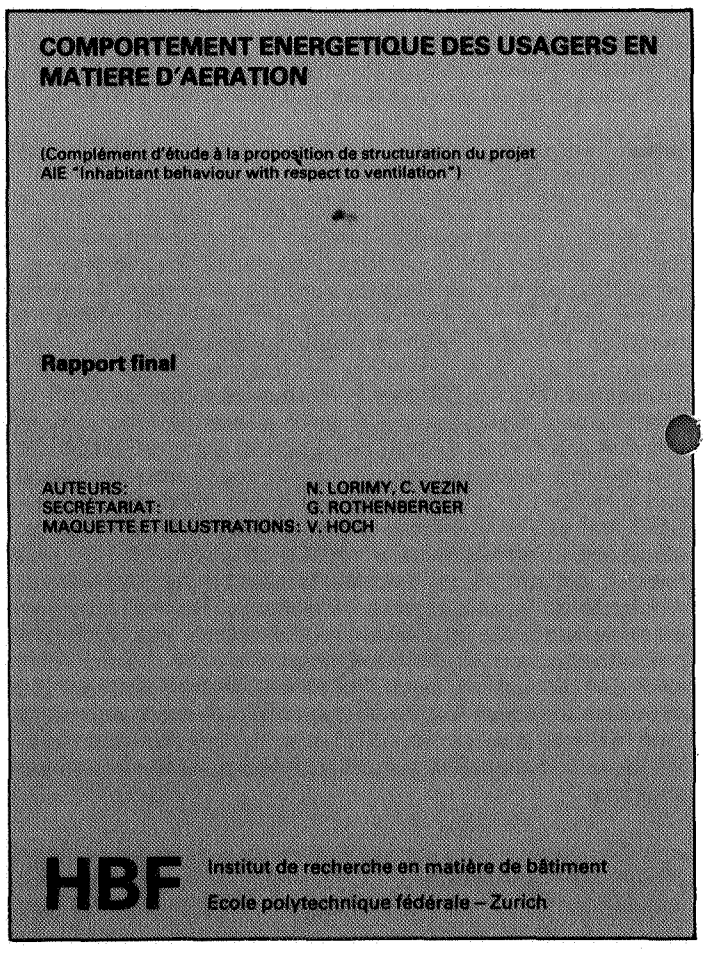
- human health and comfort
- maintenance of the condition of the building fabric
- occupant behaviour.

While the first two categories are amenable to various technical solutions (heat recovery, pre-heating of incoming air), it is suggested that occupant behaviour cannot – and should not – be treated in the same fashion.

The difficulties in influencing occupant behaviour stem from the contradictions of modern society: can a consumer society be economic in energy use? The cheap energy era has indelibly changed the material conditions of life. Energy economy has to arise from the choice of a system of values rather than from any technical advances. People are certainly not very conscious of their own energy consumption, let alone of any hidden energy costs. Politicians prefer short-term solutions, the media want spectacular results, but most energy-saving measures require long time-scales. New construction techniques have only limited impact due to the slow turnover of housing stock, so energy-saving measures must be applied to the existing housing stock, with its great variety of thermal characteristics.

The authors conclude that policy for reduction of ventilation heat loss is affected in the following ways by the influence of occupant behaviour:

- it must be part of a global energy economy package
- precipitous measures must be avoided which would increase resistance to later measures
- the contradictions of the consumer society must be overcome
- an increased energy consciousness is needed
- longer-term actions should be encouraged
- a greater participation of energy-users in decision making is necessary
- measures should be envisaged which can be applied to an existing, durable housing stock.



This report is currently available, in French, from

Swiss Federal Institute of Technology
Ramistrasse 101
8092 Zurich
Switzerland

Price: SFR 100.

6th AIC Conference

'Ventilation strategies and measurement techniques'

Het Meerdal, Netherlands
16–19 September 1985

The programme for this conference has now been finalised. A total of 34 papers will be presented by authors from 12 countries focussing attention on the factors affecting the performance of ventilation systems in a range of building types and with information for selecting the most appropriate ventilation strategies to suit specific applications. The Conference will also provide an opportunity to learn of progress in the development of techniques and instrumentation for the measurement of infiltration and ventilation.

Registration forms and complete programme details are available from your Steering Group representative (see back cover of newsletter) or direct from the Air Infiltration Centre.

Registration fee, including up to four nights inclusive accommodation and technical visit, is £214,00 sterling. Final date for receipt of registration forms is 10 August 1985.

For those unable to attend, full conference proceedings will be available directly following the conference.

Programme

Conference Programme

Monday 16 September 1985		
11.00	*Departure of coach from Schipol Airport*	
11.45	Tour of laboratory at TNO (Part 1)	
12.45	*Lunch*	
14.15	Tour of laboratory at TNO (Part 2)	
15.15	*Departure from TNO for Conference venue*	
17.00	Registration	
18.00	Reception	
20.00	*Dinner*	
Tuesday 17 September 1985		
08.30	Keynote address	
	The infiltration component of ventilation in New Zealand houses	M. Bassett (New Zealand)
	Ventilation research and characterization in three types of residences	D. Zerba et al (USA)
	The performance of ventilation in an untight house	R. Gale et al (UK)
10.15	*Coffee*	
10.45	Ventilation in dwelling houses	V. Nikolic et al (Germany)
	A passive ventilation system under trial in UK homes	K. Johnson et al (UK)
	Indoor air quality and air exchange in bedrooms	G. Lundqvist (Denmark)
	Effect of unvented combustion appliances on air exchange among indoor spaces	N. Nagda et al (USA)
12.30	*Lunch*	
14.00	Influence of open windows on the interzone air movement within a semi-detached dwelling	E. Perera et al (UK)
	Air exchange rates based upon individual room and single cell measurements	D. Harrje et al (USA)
	A study of air movements in a house using a multi-tracer measurement technique – the influence of a mechanical ventilation system and also of internal openings	R. Walker et al (UK)
	Multiple cell air movement measurements	C. Irwin et al (UK)
15.45	*Coffee*	
16.15	Continuous air renewal measurements in different inhabited buildings	J-L Scartezzini et al (Switzerland)
	The reduction of air infiltration in an industrial laboratory	J.P. Lilly et al (UK)
	Ventilation of factories	P.E. O'Sullivan et al (UK)
19.30	*Conference Dinner*	
Wednesday 18 September 1985		
08.30	Advanced energy efficient ventilation	J. Railio (Finland)
	Design for ventilation	M. Holmes (UK)
	Air quality and energy conservation by different ventilation strategies	L. Trepte (Germany)
	Exploration of ventilation strategies in domestic housing – theory and experimental results experimental results	M. Sandberg et al (Sweden)
10.15	*Coffee*	
10.45	Mechanical ventilation system requirements and measured results for homes constructed under the R-2000 super energy efficient home program	M. Riley (Canada)
	Indoor formaldehyde levels in houses with different ventilation strategies	D. Figley (Canada)
	Development of a simplified multi-zone infiltration model	H. Feustel (USA)
	Multi-cell modelling techniques	M. Sherman (USA)
12.30	*Lunch*	
14.00	*Free afternoon*	
17.30	*Buffet dinner*	
19.00	Inhabitants' behaviour with regard to ventilation – a report of the work of Annex VIII	B. Meunier and O. Van Houtte (Belgium)
	Window use in 80 apartments during a winter season	J. Phaff (Netherlands)
	Basic material for the instruction of inhabitants of dwellings. How, when and where to use your windows	W. de Gids (Netherlands)
20.15	*Coffee*	
20.45	Monitoring of ventilation and humidity in crawl- spaces of dwellings	J. Oldengarm (Netherlands)
	Ventilation strategies for crawl-spaces, attics, etc.	J. Kronvall (Sweden)
Thursday 19 September 1985		
08.30	Use of a single tracer gas for measurement of ventilation rates in a large enclosure	J. Dewsbury et al (UK)
	A multi-tracer system for measuring ventilation rates and ventilation efficiences in large mechanically ventilated buildings	W. Fisk et al (USA)
	The accuracy of constant concentration measurements	D. Bohac et al (USA)
	Ventilation system performance evaluation using tracer gas techniques	A. Persily et al (USA)
10.15	*Coffee*	
10.45	Ventilation efficiency measurements in occupied mechanically ventilated buildings	D. Dickson (UK)
	Air exchange efficiency. Infiltration, air exchange and ventilation effectiveness	E. Skaret (Norway)
11.45	Summing-up	
12.30	*Lunch*	
14.15	*Transport back to Schipol Airport*	

Forthcoming Conferences

1. Symposium on Multi-cell Infiltration
   ASHRAE Conference, Honolulu, Hawaii
   June 1985

   Further information from:

   Helmut Feustel
   Building 90, Room 3074
   Lawrence Berkeley Laboratory
   Berkeley
   California 94720
   USA
   Tel:
   Telex: 910 366 2037

2. Building Energy Simulation Conference '85
   Seattle, Washington, USA
   21 and 22 August 1985

   Further information from:

   Pamela Garland
   P.L. Garland Associates
   721 N.W. 30th Street
   Corvallis
   Oregon 97330
   USA
   Tel: 503 754 9080

3. CLIMA 2000 – Copenhagen '85
   World Congress on Heating, Ventilating and Air Conditioning
   Bella Center, Copenhagen, Denmark
   25–30 August 1985

   For further information on congress registration and booking of rooms:

   DIS Congress Service, Copenhagen
   Linde Alle 48
   DK 2720 Vanløse
   Denmark
   Tel: 01 71 22 44
   Telex: 15476 DISDK

4. 6th AIC Conference
   Ventilation strategies and measurement techniques
   Het Meerdal Park, Southern Netherlands
   16–19 September 1985

   Further information from:

   Mrs J. Elmer
   Air Infiltration Centre
   Old Bracknell Lane West
   Bracknell
   Berkshire
   RG12 4AH
   Great Britain
   Tel: +44 344 53123
   Telex: 828488 BSRIAC G

5. Ventilation '85
   1st International Symposium on Ventilation for Contaminant Control
   Toronto, Canada
   1–3 October 1985

   Further information from:

   Dr H.D. Goodfellow
   Ventilation '85
   1st International Symposium on Ventilation for Contaminant Control
   PO Box 33, Station 9
   Toronto
   Ontario
   M4T 2L7 *Tel: (416) 978 4467*
   Canada *Telex: 065 24315*

6. Thermal Performance of the Exterior Envelopes of Buildings III
   ASHRAE/DOE/BTECC Conference
   Clearwater Beach, Florida, USA
   2–5 December 1985

   Further information from:

   David T. Harrje
   Center for Energy and Environmental Studies
   The Engineering Quadrangle
   Princeton University
   Princeton
   NJ 08544
   USA *Tel: 609 452 5190*

7. 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

8. CIBS/ASHRAE 1986 Conference
   Dublin, Republic of Ireland
   14–17 September 1986

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

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

   Further information from:

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

Call For Papers

The **Energy and Buildings** journal intends to publish a special issue on **ventilation in residences** in 1986.

Papers covering the following subjects are invited to be considered for publication in this issue:

- Measurements of air change rates and/or indoor air quality.
- Development of measurement equipment.
- Simulation of ventilation.
- Economic aspects of different ventilation strategies for natural and/or mechanical ventilation.

Abstracts (approximately 100 words) describing the content of the proposed papers must be received by:

Helmut E. Feustel
Energy Performance of Buildings Group
Building 90, Room 3074
Lawrence Berkeley Laboratory
Berkeley, CA 94720

no later than Thursday 1 August 1985.

Order Form

Name .....

Organisation .....

Address .....

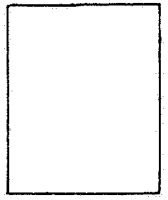
.....

	Non-participants £ sterling	Participants £ sterling
Please add my name to your mailing lists as follows:		
Air Infiltration Review ..... copies (quarterly)	Free	Free
Recent Additions to *AIRBASE* ..... copies (quarterly)	Not available	Free
Please forward the following publications:		
Technical Note AIC-TN-5-81 ..... copies	10.00	Free
AIC-TN-5.1-83 ..... copies	7.50	Free
AIC-TN-5.2-84 ..... copies	7.50	Free
AIC-TN-5.3-84 ..... copies	10.00	Free
AIC-TN-6-81 ..... copies	6.00	Free
AIC-TN-10-83 ..... copies	Not available	Free
AIC-TN-11-83 ..... copies	Not available	Free
AIC-TN-12-83 ..... copies	Not available	Free
AIC-TN-13-84 ..... copies	Not available	Free
AIC-TN-13.1-84 ..... copies	Not available	Free
AIC-TN-14-84 ..... copies	Not available	Free
AIC-TN-15-84 ..... copies	Not available	Free
Literature List No. 1 ..... copies	Not available	Free
No. 2 ..... copies	Not available	Free
No. 3 ..... copies	Not available	Free
No. 4 ..... copies	Not available	Free
No. 5 ..... copies	Not available	Free
No. 6 ..... copies	Not available	Free
No. 7 ..... copies	Not available	Free
No. 8 ..... copies	Not available	Free
No. 9 ..... copies	Not available	Free
No. 10 ..... copies	Not available	Free
No. 11 ..... copies	Not available	Free
No. 12 ..... copies	Not available	Free
1st Conference Proceedings ..... copies	35.00	35.00
2nd Conference Proceedings ..... copies	15.00	15.00
3rd Conference Proceedings (2 vols.) ..... copies	23.50	23.50
4th Conference Proceedings (2 vols.) ..... copies	16.00	16.00
5th Conference Proceedings (2 vols.) ..... copies	16.00	16.00
Handbook ..... copies	12.00	12.00

I enclose a cheque made payable to BSRIA (AIC) for: £ ..... drawn on a UK bank

Signed .....Dated .....

3rd fold (insert in Flap A)



Air Infiltration Centre
Old Bracknell Lane West
Bracknell
Berkshire
RG12 4AH
Great Britain

2nd fold (Flap A)

1st fold

AIC Publications List

PERIODICALS

Air Infiltration Review
Quarterly newsletter containing topical and informative articles on air infiltration research and application. Also gives details of forthcoming conferences, recent acquisitions to *AIRBASE* and new AIC publications.
Unrestricted availability, free-of-charge.

Recent Additions to *AIRBASE*
quarterly bulletin of abstracts added to *AIRBASE,* AIC's bibliographic database. Provides an effective means of keeping up-to-date with published material on air infiltration and associated subjects. Copies of papers abstracted in 'Recent Additions to *AIRBASE*' can be obtained from AIC library.
Bulletin and copies of papers available free-of-charge to participating countries only.*

TECHNICAL NOTES

AIC-TN-1-80 – Out of Print – to be revised.

AIC-TN-2-80 – Superseded by AIC-TN-7-81.

AIC-TN-3-81 – Superseded by AIC-TN-8-82.

AIC-TN-4-81 – Superseded by AIC-TN-10-83.

AIC-TN-5-81 – Allen, C.
'AIRGLOSS: Air Infiltration Glossary (English edition)', 124pps.
Contains approximately 750 terms and their definitions. Related to air infiltration, its description, detection, measurement, modelling and prevention as well as to the environment and relevant physical processes.
Available free-of-charge to participating countries. Price: £10 to non-participating countries.*

AIC-TN-5.1-83 – Allen, C.
'AIRGLOSS: Air Infiltration Glossary (English-German/Deutsch-Englisch) Supplement' 58pps.
A supplement containing translations of the terms published in AIRGLOSS.
Available free-of-charge to participating countries. Price £7.50 to non-participating countries.*

AIC-TN-5.2-84 – Allen, C.
'AIRGLOSS: Air Infiltration Glossary (English – French/Français – Anglais) Supplement'
A supplement containing translations of the terms published in AIRGLOSS.
Available free-of-charge to participating countries. Price £7.50 to non-participating countries.*

AIC-TN-5.3-84
'AIRGLOSS: Air Infiltration Glossary (Italian Edition)' 80pps.
An Italian version of the original English glossary (TN-5-81).
Available free-of-charge to participating countries. Price £10 to non-participating countries.*

AIC-TN-6-81 – Allen, C.
'Reporting format for the measurement of air infiltration in buildings', 56pps.
Produced to provide a common method for research workers to set out experimental data, so assisting abstraction for subsequent analysis or mathematical model development. May be used directly for entering results and as a useful checklist for those initiating projects. Example of use of format is included as an appendix.
Available free-of-charge to participating countries. Price: £6 to non-participants.*

AIC-TN-7-81 – Superseded by AIC-TN-12-83.

AIC-TN-8-82 – Superseded by AIC-TN-15-84.

AIC-TN-9-82 – Superseded by AIC-TN-11-83.

AIC-TN-10-83 – Liddament, M., Thompson, C.
'Techniques and instrumentation for the measurement of air infiltration in buildings – a brief review and annotated bibliography', 60pps.
Four-section bibliography contains review papers, information on tracer gas techniques, pressurization methods and miscellaneous approaches. In addition the report contains list of manufacturers of instrumentation currently being used in air infiltration investigations.
Available free-of-charge to participating countries only.*

AIC-TN-11-83 – Liddament, M., Allen, C.
'The validation and comparison of mathematical models of air infiltration', 124pps.
Contains analysis of ten models developed in five participating countries. These range in complexity from 'single-cell' to 'multi-cell' approaches. Also contains numerical and climatic data for fourteen dwellings compiled to produce three key datasets which were used in model validation study.
Available free-of-charge to participating countries only.*

AIC-TN-12-83 – Liddament, M.
'1983 Survey of current research into air infiltration and related air quality problems in buildings', 100pps.
3rd worldwide survey by AIC, containing over 170 replies from 22 countries. Produced in two sections: an analysis in tabular form of survey results, followed by reproduction in full of research summaries, and appendix containing names and addresses of principal researchers.
Available free-of-charge to participating countries only.*

AIC-TN-13-84 – Allen, C.
'Wind Pressure Data Requirements for Air Infiltration Calculations'
An up-to-date review of the problems associated with satisfying the wind pressure data requirements of air infiltration models.
Available free-of-charge to participating countries only.*

AIC-TN-13.1-84
'1984 Wind Pressure Workshop Proceedings'
Report of written contributions and discussion at Workshop held in March 1984, Brussels.
Available free-of-charge to participating countries only.*

AIC-TN-14-84 – Thompson, C.
'A Review of Building Airtightness and Ventilation Standards', 74pps
Lists and summarises airtightness and related standards to achieve energy efficient ventilation.
Available free-of-charge to participating countries only.*

AIC-TN-15-84 – Thompson, C.
'A subject analysis of the AIC's bibliographic database – *AIRBASE.*' 3rd Edition, 104 pps.
Comprehensive register of published information on air infiltration and associated subjects. The articles are indexed by subject and full bibliographic details of the 1276 papers are given. A list of principal authors is also included.
Available free-of-charge to participating countries only.*

LITERATURE LISTS – Listing of abstracts in *AIRBASE* on particular topics related to air infiltration.

No. 1 Pressurization – Infiltration Correlation: 1. Models (17 references).
No. 2 Pressurization – Infiltration Correlation: 2. Measurements (26 references).
No. 3 Weatherstripping windows and doors (24 references).
No. 4 Caulks and sealants (24 references).
No. 5 Domestic air-to-air heat exchangers (25 references).
No. 6 Air infiltration in industrial buildings (14 references).
No. 7 Air flow through building entrances (22 references).
No. 8 Air infiltration in commercial buildings (28 references).
No. 9 Air infiltration in public buildings (10 references).
No. 10 CO_2 controlled ventilation (13 references).
No. 11 Occupancy effects on air infiltration (15 references).
No. 12 Windbreaks and shelter belts (19 references).

CONFERENCE PROCEEDINGS

No. 1 'Instrumentation and measuring techniques'.
1st AIC Conference, 6–8 October 1980, Windsor, Berkshire, UK, 372pps, £35.00 sterling.
No. 2 'Building design for minimum air infiltration'.
2nd AIC Conference, 21–23 September 1981, Stockholm, Sweden, 216pps, £15.00 sterling.
No. 3 'Energy efficient domestic ventilation systems for achieving acceptable indoor air quality'.
3rd AIC Conference, 20–23 September 1982, London, UK, 432pps and Supplement 160pps. Total cost £23.50 sterling.
No. 4 'Air infiltration reduction in existing buildings'.
4th AIC Conference, 26–28 September 1983, Elm, Switzerland, 342pps and Supplement 52pps. Total cost £16.00 sterling.
No. 5 'The implementation and effectiveness of air infiltration standards in buildings'.
5th AIC Conference, 1–4 October 1984, Reno, Nevada, USA. 376pps and Supplement. Total cost £16.00 sterling.

HANDBOOK – Elmroth, A., Levin, P.
'Air infiltration control in housing. A guide to international practice', 410pps.
An international guide to airtightness design solutions of great practical value to all those concerned with the design of pollution-free dwellings with low energy demands. Price: £12.00 sterling.

**The participating countries are: Belgium, Canada, Denmark, Finland, The Federal Republic of Germany, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom and the United States of America.*

Representatives and Nominated Organisations

Belgium

*P. Caluwaerts,
Belgian Building Research Institute,
Lombard Street 41,
1000 Brussels.
Tel: 02-653-8801/02-511-0683
Telex: 256 82

P. Nusgens,
Université de Liège,
Laboratoire de Physique du Bâtiment,
Avenue des Tilleuls 15-D1,
B-4000 Liège,
Belgium.
Tel: 041-52-01-80
Telex: 41746 Enviro B.

Canada

*R. Dumont,
Division of Building Research,
National Research Council,
Saskatoon,
Saskatchewan,
Canada S7N 0W9.
Tel: 306-665-4200
Telex: 074 2471

J. Shaw,
Division of Building Research,
National Research Council,
Ottawa,
Canada K1A 0R6.
Tel: 613-993-1421
Telex: 0533145

J.H. White,
Research Division,
Canada Mortgage and Housing Corporation,
Montreal Road,
National Office,
Ottawa, Ontario,
Canada K1A 0P7.
Tel: 613-748-2309
Telex: 053/3674

Denmark

*P.F. Collet,
Technological Institute,
Byggeteknik,
Post Box 141,
Gregersensvej,
DK 2630 Tastrup, Denmark.
Tel: 02-996611
Telex: 33416

Finland

*S. Ahvenainen/R. Kohonen,
Technical Research Centre,
Laboratory of Heating and Ventilation,
Lampomiekenkuja 3,
SF-02150 Espoo 15,
Finland.
Tel: 358 04564742
Telex: 122972 VTTHA SF

*Steering Group Representative.

***Federal Republic of Germany**

L.E.H. Trepte,
Dornier System GmbH,
Postfach 1360,
D–7990 Friedrichshafen 1,
Federal Republic of Germany.
Tel: 07545 82244
Telex: 734209-0 DO D

A. Le Marié
Projektleitung Energieforschung in
der KFA Jülich GmbH
Postfach 1913
D–5170 Jülich
Federal Republic of Germany
Tel: 02461 616977
Telex: 833556 KFA D

Netherlands

*W. de Gids,
Institute for Environmental Hygiene – TNO,
P.O. Box 214,
Delft,
Netherlands.
Tel: 015-569330
Telex: 38071

New Zealand

*H.A. Trethowen,
Building Research Association of New Zealand Inc
(BRANZ),
Private Bag,
Porirua,
New Zealand.
Tel: Wellington 04-357600
Telex: 30256

Norway

*J.T. Brunsell,
Norwegian Building Research Institute,
Box 322,
Blindern,
N-0314 Oslo 3,
Norway.
Tel: 02-46-98-80

S. Uvsløkk,
Norwegian Building Research Institute,
Høgskoleringen 7,
N-7034 Trondheim – NTH,
Norway.
Tel: 07-59-33-90

Sweden

*L.G. Månsson,
Swedish Council for Building Research,
St. Göransgatan 66,
S-112 33 Stockholm,
Sweden.
Tel: 08-540640
Telex: 10398

F. Peterson,
Royal Institute of Technology,
Dept. of Heating and Ventilating,
S-100 44 Stockholm,
Sweden.
Tel: 08-7877675
Telex: 10389

Switzerland

*P. Hartmann, EMPA,
Section 176,
Ueberlandstrasse,
CH 8600 Duebendorf,
Switzerland.
Tel: 01-823-4276
Telex: 53817

The Oscar Faber Partnership (UK)

*S. Irving,
The Oscar Faber Partnership,
Marlborough House,
Upper Marlborough Road,
St. Albans,
Herts, AL1 3UT,
Great Britain.
Tel: 0727-59111
Telex: 889072

H. Danskin,
Building Research Energy Conservation
Support Unit (BRECSU),
Building Research Establishment,
Bucknalls Lane, Garston,
Watford,
Herts, WD2 7JR,
Great Britain.
Tel: 0923-674040
Telex: 923220

BSRIA,
Old Bracknell Lane West,
Bracknell,
Berks, RG12 4AH,
Great Britain.
Tel: 0344-426511
Telex: 848288

USA

*M. Sherman,
Energy and Environment Division,
Building 90, Room 3074,
Lawrence Berkeley Laboratory,
Berkeley, California 94720,
USA.
Tel: 415/486-4022
Telex: 910-366-2037

R. Grot,
Building Thermal and Service Systems Division,
Centre for Building Technology,
National Bureau of Standards,
Washington D.C. 20234,
USA.
Tel: 301/921-3470

J. Smith,
Department of Energy,
Buildings Division,
Mail Stop GH-068,
1000 Independence Avenue S.W.,
Washington D.C. 20585,
USA.
Tel: 202/252-9191
Telex: 710 822 0176

D. Harrje,
Centre for Energy and Environmental Studies,
Princeton University,
Princeton, New Jersey 08544,
USA.
Tel: 609-452-5190/5467

AIC

Published by

Air Infiltration Centre,
Old Bracknell Lane West,
Bracknell,
Berkshire, RG12 4AH,
Great Britain.

ISSN: 0143-6643

Tel: National 0344 53123
International +44 344 53123

Telex: 848288 (BSRIAC G)

Head of AIC: Peter J. Jackman,
BTech CEng MIMechE FCIBSE

Operating Agent: The Oscar Faber Partnership