Air Infiltration Review

a quarterly newsletter from the IEA Air Infiltration and Ventilation Centre

International Energy Agency - AIVC

Vol. 11, No. 3, June 1990

Field Monitoring for a Purpose

by D.T. Harrje, Visiting Specialist, AIVC,

February-April, 1990

Field monitoring in pursuit of more energy-efficient buildings and components has undergone a revolution during the past decade. One major influence has been the benefits derived from the capabilities of the micro-computer: conditioning field data, reaching high standards of data recording, allowing one to send the data via modems and phone lines to distant monitoring stations, and supplying the ability to instantly calculate meaningful engineering parameters that indicate whether the monitoring effort is actually making sense. Arne Boysen, the organiser and chairperson of an April conference/workshop on Field Monitoring - For a Purpose, recognised the need for experts to explore the direction of future IEA projects involving field monitoring in the light of the rapid changes taking place and new requirements being imposed in this field of activity. The experts were from three IEA committees, all with similar goals in this area, Energy Conservation in Building and Community Systems, Solar Research and Development and CADDET. The site of the conference was Chalmers University of Technology in Gothenburg, Sweden, with Professor Torbjorn Jilar the meeting host.

The conference/workshop used eight invited keynote papers to set the tone of the meeting. Three working groups were pre-selected from the 50 experts attending the conference, who represented 10 IEA countries. There was suggested criteria for working group guidance in viewing future IEA projects, namely: projects should be planned and executed to provide reliable results while including data necessary for general project assessments; results should be based upon the use of recognised and validated techniques; results should be presented to achieve the desired impact on the key audiences; and the true costs and other limiting factors of field monitoring projects should be recognised.

The Keynote Topics

Planning and design of field experiments was the first keynote topic. Here ambitions and purpose of field

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studies, what is really involved in such studies, and what are the organisational requirements were discussed

Topic number two was the design of field experiments and demonstrations. Different experimental designs were reviewed together with their characteristic features and applicability. Relationships between the design and the extent of monitoring, looking at analytical and statistical approaches, were reviewed. Analysis of methodological errors and the requirements for accuracy of measurement were placed in perspective.

Next the monitoring plan and data quality control were covered by keynote paper three. Such items as data requirements, quality, quantity and time resolution were reviewed. Generic requirements of the monitoring system, which includes data loggers, sensors and related hardware, were placed in perspective. When and how the data should be processed were covered here.

Keynote topic four moved into the use of numerical simulations of the physical system. Simulation as a tool for planning the monitoring effort, as well as assisting in the analysis of the experiments were discussed. The question was posed: Could simulation substitute for field monitoring?

Keynote topic 5 was covered in the morning of the second day, and concentrated on analysis and conclusions of field experiments as well as presentation of results. Topics included; the stochastic factors in field monitoring, weather and building occupancy. Together with a detailed review of these key factors, the topics of reduction of systematic errors and the generalisation of results were covered.

Topic 6 dealt with software tools for the analysis of field measurements. Dynamic analysis, statistical analysis and graphical packages were reviewed.

The important topics of data acquisition and control were covered next. How to compensate for missing data, the role of interim reports and analyses, and detection of erroneous data were part of these discussions.

The final keynote topic dealt with presentation of results. What reporting format to use, how to structure recommendations and even the use of film and video fell under this topic heading.

Air Infiltration Review

Editor: Janet Blacknell

Air infiltration Review has a quarterly circulation of 3,500 copies and is currently distributed to organisations in 40 countries. Short articles or correspondence of a general technical nature related to the subject of air infiltration and ventilation are welcome for possible inclusion in AIR. Articles intended for publication must be written in English and should not exceed 1,000 words in length. If you wish to contribute to AIR, please contact Janet Blacknell at the Air Infiltration and Ventilation Centre.

Conclusions and opinions expressed in contributions to Air Infiltration Review represent the author(s)' own views and not necessarily those of the Air Infiltration and Ventilation Centre.

Countries receiving Air Infiltration Review

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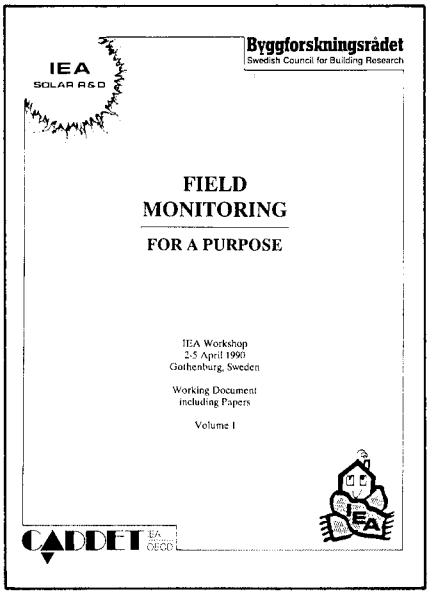
The Role of the Working Groups

Three working groups were used to probe the field monitoring topics in greater depth. Depending on the backgrounds of the experts, the field monitoring experiences in countries they represented, and the presentations made during two lengthy working group sessions, each working group viewed the eight keynote topics somewhat differently. This was done purposely to encourage a diversity of opinion on each topic by the three small working groups. The variety of backgrounds was very evident within the working groups where participants ranged from funding agency personnel to participants who were involved in daily field monitoring operations. Although the technical presentations given in one working group were completely different from the new information provided to the two other working groups, two bound volumes containing the written information that had been contributed to the meeting organisers served as reference material for all participants. Although the input to the three working groups was varied, the mandate was the same, namely: to provide guidance to future IEA projects.

Results of the Conference/Workshop

The three working group recommendations on the conference goals were anticipated to be different, and indeed they were in many respects, but there also was a very real consensus on what constituted key topics for future projects. The final working group session brought the three groups together. Points of agreement were discussed, supplying a fourth record of what subjects were considered important. The three working group recommendations and those items discussed in the summary session are now being consolidated into a single report where the working group chairpersons will be part of the review process. Interim reports to the interested IEA committees are being made by the conference chairperson. The final document covering the conference recommendations should be availabe in September, 1990.



General Observations

Field monitoring of buildings and related systems has advanced rapidly over the last decade. The role of the microcomputer has been very evident in these changes. A realisation that installation costs often dominate project economics has given new impetus to seeking alternative monitoring designs that avoid hard wiring. Battery-powered local data acquisition, monitoring using power line carrier approaches, or other non intrusive methods, are clearly the wave of the future.

Demonstrations of advanced instrumentation, data acquisition, and data analysis techniques represented one key aspect of the conference. For example, an almost indestructable temperature sensor-recorder, with a nine year lifespan, is commercially in use monitoring refrigeration vehicles to document that frozen food temperatures are maintained throughout the journey to market. Data is accessed via computer at the end of the trip. This is just one example of field monitoring trends. Emphasis in working group discussions covered topics such as: continuous and early project reporting is needed to maximise monitoring benefits; use of simulation and shorter monitoring periods offer a possible way to control costs; error analysis and energy balance calculations should be the entry point to project planning; selected, sensitive variables, such as air infiltration, should be the principal candidates for continuous monitoring; there is a need for improved information exchange between project analysis groups, monitoring teams and designers; much can be gained from formal guidance in areas of emerging products and technologies such as micro-computer-based sensors and electromagnetic system interference, as well as in the area of data formats and/or monitoring protocols; coordination between field monitoring involved groups and projects would likely result in improved field data and datasets which can answer a wider spectrum of building-related questions; funding for those well-planned field monitoring efforts is vital for future advancements in this dynamic field. Some of these points represent a view from one working group, the final report should supply additional perspectives from the workshop as a whole.

The proceedings of this conference are available on loan from AIVC Information Services, or for retention by contacting the following address:

CADDET,
PO Box 17,
6130 AA Sittard,
Netherlands

Ventilation and "Building Sickness" - A Brief Review

Martin Liddament, Head of AIVC

Introduction

As the thermal performance of buildings continues to improve, air exchange will eventually become the dominant mechanism for building heat loss. Although, therefore, an essential parameter of the energy equation, ventilation is nevertheless vital for the dilution and removal of pollution generated within buildings. An inadequate supply of fresh air or poor air distribution will result in high levels of indoor contaminants, discomfort and a poor living environment, it could also result in more serious health related problems. As a consequence, reduced air change as a means to minimise energy demand has become inextricably linked to the problems associated with unhealthy buildings. The purpose of this note is to summarise some of the International Energy Agency related and other activities in this field and to introduce the AIVC's Literature List on "Sick Buildings".

Minimum ventilation rates to secure adequate indoor air quality have been the subject of intensive investigation within the International Energy Agency and elsewhere. Recent publications on the subject include AIVC Technical Note 26, which describes the work of IEA Annex 9 on measures to control indoor air quality (Trepte 1989) and ASHRAE Standard 62-1989 on Ventilation for Acceptable Indoor Air Quality (ASHRAE 1989) (Figure 1). Technical Note 26 provides a summary of common building source characteristics, in terms of the origin and special features of pollutants (ie the effects of pollutants in relation to risk, annoyance and damage to building fabric), control measures such as source control and ventilation, and ventilation strategies.

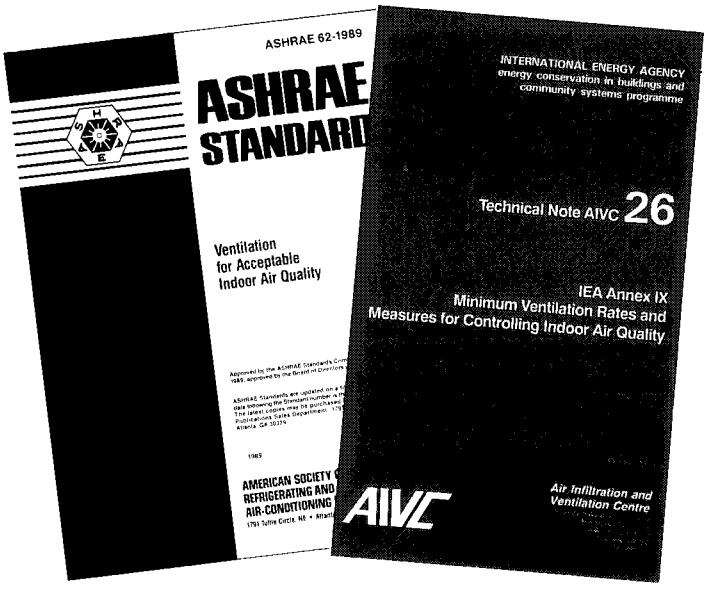


Figure 1 Recent publications on minimum ventilation

In many instances, the control of pollution should involve the restriction or elimination of the polluting source but often it falls upon ventilation to provide an answer. The derivation of minimum ventilation rate is dependent on identifying the dominant pollutant, its source strength and its maximum acceptable indoor concentration. Often the maximum permissible concentration of a pollutant is dependent on environment and exposure times. Thus, in an industrial area for example, concentrations are often expressed in terms of 1 hour or 8 hour exposure period threshold limit values. These are set with health and safety as prime concerns and, for many pollutants, are concentration levels which would be wholly unacceptable in an office or dwelling, where other factors such as intrusive odour would create discomfort. Acceptable concentrations of many common pollutants, for various occupancy conditions, are summarised in the appendix section of ASHRAE Standard 62-1989.

Where energy conservation is of concern, the need to provide ventilation above what would normally be necessary, in order to mitigate a particular pollution problem (eg tobacco smoke), can be directly equated in terms of extra energy consumption and hence additional costs.

AIVC "Sick Buildings" Literature List

While by no means an exhaustive reference list on the subject, a search of the term "sick buildings" in the Air Infiltration and Ventilation Centre's Bibliographic Database - AIRBASE reveals over 90 references. These have recently been compiled into a Literature list which is available from the Centre. A brief analysis of these articles reveal several suggestions as to the causes of the problem. These can essentially be categorised into the following three broad themes:

- ventilation system performance
- contaminants
- other parameters

A summary of the first theme is presented in Table 1. While insufficient or inadequate ventilation was widely cited as a cause, and in many instances is undoubtedly a contributory factor, the measurement of air change is, as yet, not a common feature of air quality investigations. Without having routine knowledge of air change rates, it is probably difficult to prescribe sensible adjustments to ventilation rates in order to improve building air quality. To facilitate an understanding of measurement methods, the AIVC has published a handbook on measurement techniques (Charlesworth 1988). This provides comprehensive guidance on the range of techniques available and on how they should be applied. In addition IEA Annex 20,

which is concentrating effort on the calculation and measurement of air flow patterns within buildings, is currently producing an update to the AIVC handbook to incorporate the measurements of room air flow and air leakage in multi-zone structures.

Other ventilation related problems found in the literature relate to excessive air change, leading to discomfort through insufficient heating or cooling, and general failures in the ventilation or air conditioning system as a result of either poor maintenance or design.

Table 1 Reasons for "Sick" Buildings

1 - Ventilation Systems

- Ventilation too low
- Ventilation too high
- Inoperative Ventilation System
- Air Conditioning
- Poor Filtration
- Poor Maintenance

Building contaminants investigated as part of indoor air quality studies are listed in Table 2. Some, such as asbestos and formaldehyde, are specific to building components or choice of thermal insulation. Others, such as outdoor pollution and radon are more dependent on building location, although much can be achieved through good building design to eliminate radon problems. The remainder tend to be contaminants which depend on building use and occupancy patterns. Since, over time, the pattern of building use can vary, the relative concentrations of occupant generated pollutants and hence ventilation needs may also vary.

Odour is widely used as an indicator of air quality, although it provides no warning of dangerous odourless gasses such as radon and carbon monoxide. The quantitative measurement of odour using instruments is not possible but a subjective approach has been developed by Fanger (1988). This technique introduces the unit of "OLF" as a measure of the emission rate of pollutant from a "standard" sedentary person and the "decipol", which is the pollution caused by one standard person ventilated by 10 l/s of unpolluted air. A specially trained team of assessors is needed to evaluate odour within a room by making comparisons with known decipol levels established by a reference gas. A full description of this technique is published by Bluyssen (1988) in the February 1989 edition of "Air Infiltration Review".

Since Fanger's approach to the classification of odour levels demands a trained panel of specialists, its

Table 2 Reasons for "Sick" Buildings

2 - Building Contaminants

- Asbestos
- Carbon Dioxide
- Carbon Monoxide
- Dust
- Formaldehyde
- Fungal Spores
- Humidity (too high, too low)
- Ions
- Odour
- Outdoor Pollution
- Ozone
- Radon
- Smoke
- Volatile Organic Compounds

widespread application is, as yet, limited. Instead, carbon dioxide concentration is often used as a measure of occupancy and occupancy generated pollution.(Figure 2) ASHRAE Standard 62-1989 sets an upper concentration limit of 1000ppm for comfort (odour) criteria. Because carbon dioxide concentration, along with other occupant generated pollutants such as moisture, can be measured with relative ease, appropriate detectors are beginning to be used in the monitoring and control of ventilation rates, especially in

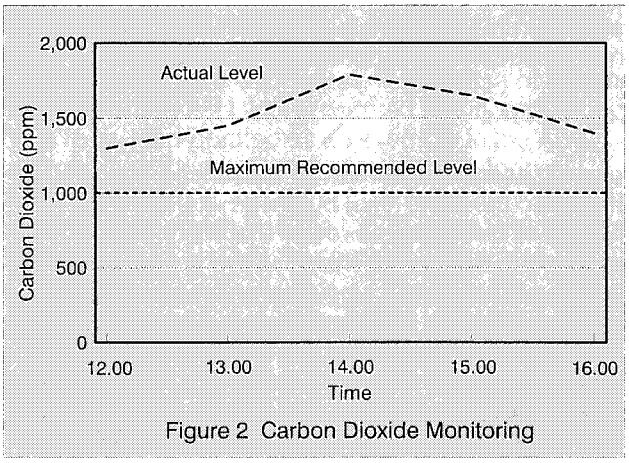


Figure 2 Carbon Dioxide Monitoring

transiently occupied buildings. This topic is being investigated in detail by IEA Annex 18 on "Demand Controlled Ventilation" (Raatschen and Mansson 1990). The principal objective of this task is to develop guidelines for demand controlled ventilation systems based on the varying needs of domestic, office and other environments. While essentially focusing on carbon dioxide and humidity sensors for ventilation control, mixed gas, tobacco smoke and carbon monoxide sensors are also being considered. Additional work, within Annex 18, includes the development of guidelines for the implementation of demand controlled ventilation systems.

Table 3 Reasons for "Sick" Buildings

3 - Other Parameters
Psychological Factors
No User Control
Stress
Noise
Lighting

The control of indoor climate by the actions of occupants has also been investigated by IEA Annex 8 (Dubrul 1988). This work concentrates on how occupants satisfy ventilation needs and possible ways of improving user efficiency.

Other reasons which are cited in the literature as causes of "sick buildings" are indicated in Table 3. These problems are beyond the scope of the Air Infiltration and Ventilation Centre but include psychological or work related problems, the absence of user controls (eg openable windows), excessive noise and inadequate or inappropriate lighting.

Conclusions

For a full analysis of AIRBASE references, readers are referred to the AIVC "sick buildings" literature list. An analysis of these papers reveal that there are many possible problems which result in unhealthy buildings and it is unlikely that a single common cause exists. However it is clear that ventilation is perceived to have an important role to play in the avoidance of such problems. In order to ensure that a full understanding between pollutant levels and ventilation can be clearly understood, the measurement of air change rates and air flow patterns needs to form a fundamental aspect of any building air quality study. Appropriate measurement techniques varying from relatively inexpensive passive sampling methods to comprehensive interzonal air flow measurement methods are now well established and it is up to researchers in this field to implement these techniques more widely in their studies.

On the theoretical front, the concepts of air change efficiency and ventilation effectiveness need to be rationalised and adapted to provide quantitative links between measurement results and pollutant concentrations. The AIVC has recently published a Technical Note on air change efficiency (Sutcliffe 1990) and is currently preparing a review on ventilation effectiveness in relation to the removal of airborne pollutants.

Of related interest to this topic is AIVC Technical Note 30, to be published in July, which contains an up to date summary of standards in AIVC countries on airtightness and ventilation requirements.

References

ASHRAE Standard 62-1989 "Ventilation for acceptable indoor air quality" American Society for Heating, Ventilation and Air-Conditioning Engineers 1989 ISSN 1041-2336

Bluyssen P "Olfbar" Air Infiltration Review, Vol 10 No. 2 1989

Charlesworth P.C "Air exchange rate and airtightness measurement techniques - an applications guide" Air Infiltration and Ventilation Centre 1988

Colthorpe K, "A review of air infiltration and ventilation standards", AIVC Technical Note 30, July 1990.

Dubrul C, "Inhabitant behaviour with respect to ventilation - a summary report of IEA Annex 8, Technical Note AIVC 23, Air Infiltration and Ventilation Centre, 1988.

Fanger P.O "Introduction of the olf and decipol units to quantify air pollution perceived by humans indoors and outdoors" Energy and Buildings, Vol 12 1988

Raatschen W and Mansson L.G "State of the art review about demand controlled ventilation systems completed" Air Infiltration Review Vol 11 No.2 1990

Sutcliffe H "A guide to air change efficiency" Technical Note AIVC 28 Air Infiltration and Ventilation Centre 1990

Trepte L and Haberda F "IEA annex IX minimum ventilation rates and measures for controlling indoor air quality" Technical Note AIVC 26 Air Infiltration and Ventilation Centre 1989

AIVC Database Workshop March 19-20th 1990

James Piggins, Scientist, AIVC

In conjunction with its semi-annual Steering Group meeting, the Air Infiltration and Ventilation Centre held a specialist workshop on the development of the numerical database. This was attended by 27 experts from the AIVC participating countries, and was chaired by Max Sherman, of Lawrence Berkeley Laboratory, USA. The main objectives/tasks of this workshop were as follows:

- Review user needs

- Revise AIVC Technical Note 6 (TN6) - "Reporting format for the measurement of air infiltration in buildings"

- Develop links with related activities

- Assess available data

- Establish user input/output mechanisms

Martin Liddament, Head of the Centre introduced the workshop by outlining a brief history of the numerical database; James Piggins, Project Scientist, then outlined the philosophy and intended contents of the database. Discussion centred on the need to define the prospective user and user needs; these included:

- Model Evaluation

- Stock Characterisation

- Design data for energy, ventilation, air quality and economic assessments

Following this discussion, David Harrje of Princeton University, USA and visiting specialist to the AIVC, outlined the proposed revision of AIVC TN6. This standardised reporting format was produced by the Centre in 1981 to provide a common method for research workers to set out their experimental data, so making the information easy to extract for subsequent analysis or mathematical model development. The work on the numerical database highlighted a number of new needs, so necessitating its revision. Most changes to the standard reporting format will involve better guidance as to its use and requirements for more detailed and/or specific information than before. All changes will be made with regard to data usage by other researchers and the numerical database, as well as ensuring no information of future value to the researcher is omitted from the reporting process. Participants were requested to review the proposed document and report their conclusions. Following this review a number of additional changes were proposed. These included the following suggestions:

- The Technical Note should act both as a "Front End" and a check list for required project data.

- Data should be classified according to its required use and importance.

- An estimation of accuracy was considered essential. In particular the accuracy of the method and the instrumentation used should be assessed. It was suggested that the measurement instrument used should be specified and cross references made wherever possible to the AIVC Measurement Techniques Guide.

- To assist in data input a dBASE IV application package should be produced. This would act as a semi intelligent input program prompting the user according to his needs for the required data. It would also produce a printed report for use by the user.

With regard to data quality and accuracy, Don Colliver of the University of Kentucky, USA, gave a presentation on "Data integrity in blower door leakage measurements". He also outlined his review and measurement work on component leakages, an area highlighted by the workshop as particularly important to the database for model evaluation studies.

The interaction of the COMIS project (AIR June 1989) and the database was outlined by Helmut Feustel of the COMIS group, based at Lawrence Berkeley Laboratory, USA. This also highlighted the need for component leakage, as well as pressure coefficient and weather data for computer modelling purposes. In conjunction with the COMIS project, Victor Dorer of EMPA, Switzerland described and gave a demonstration of interfacing the COMERL model (an adaptation of the COMIS model for the Swiss ERL project), with data using a dBASE IV application he has developed.

Claude-Alain Roulet of LESO-EPFL, Switzerland discussed meteorological data, in particular the extrapolation of local winds from remote weather stations (Figure 1). He also talked about inhabitant behaviour, detailing the development of behaviour algorithms from the LESO-EPFL building. This particular building is of three storey construction which has been specifically instrumented for monitoring multizone air flow and occupancy patterns (Figure 2).A full description of the building was presented by Jean-Marie Furbringer of LESO. Principal parameters include dimensions, air leakage paths, pressure coefficients and ventilation rates. A database of existing LESO measurements was presented to the workshop and is to be incorporated as an example in the AIVC data reporting format. These data will also form a fundamental input to future multizone model validation exercises. Discussions on the LESO presentation were followed by a review of other potential data sets.

Dissemination mechanisms were detailed in brief by Martin Liddament and consisted of a number of options dependent on the users' required needs. These included:

- Full database access. To access the full database the user needs dBASE IV software. This will enable direct

use and manipulation of the data according to user needs.

- Applications packages. Users will be able to use the applications packages developed by the Centre and others without purchasing dBASE IV itself. The first example of this will be a package based on the revised TN6. As described above this will allow the easy selection, entry and editing of the required base data for a particular project and produce a finished report. It will also allow a record of any associated data files whether in dBASE format or not, and will have facilities to import data files produced externally to dbase. As a further example a basic application package interfacing the database with a simple multizone model was demonstrated at the workshop by James Piggins. This will be expanded into an example output protocol allowing model developers to interface their models directly to the database.

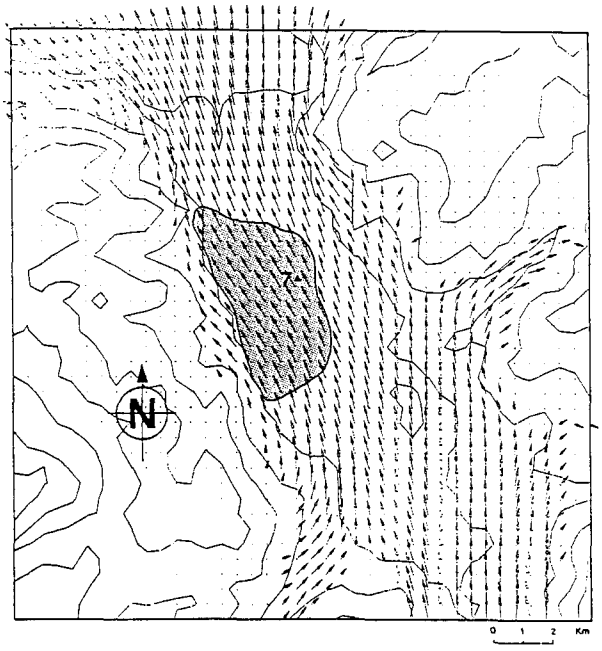


Figure 1 Wind vectors in vicinity of a meteo station. Dashed area shows the limited representivity of the data.

- AIVC Guides. For those who wish to work on specific areas and have no particular need for a sophisticated computer package, hard copy versions of specific portions of the database will be available.

- Technical enquiry service. The database will be used to extend the technical enquiry service offered by the Centre wherever possible.

The final discussions led to a summary given by Martin Liddament of the additional requirements for the database highlighted by the workshop. These included:

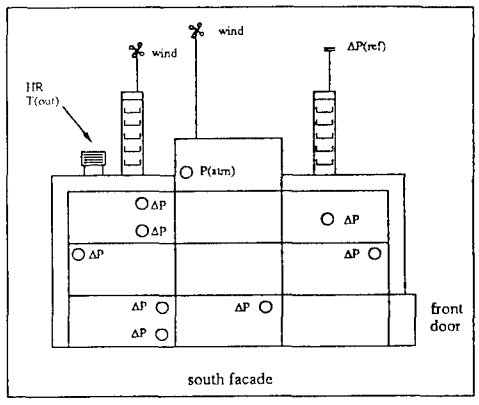


Figure 2 South facade of the LESO building with meteorological parameters probes position.

- Hierarchical data classification. A hierarchical structure was needed to classify the usefulness of any data. Thus, for example, "C" & "n" values would be useful in most leakage applications as they could be used to derive other less exact leakage parameters such as air change at 50 Pa and Equivalent Leakage Area (ELA), but air change and ELA data cannot be used where "C" & "n" are required.

- Relevant algorithms should be included wherever possible, e.g. where wind data is given, algorithms for converting data to local values should be given.

- Manipulated data or data corrected for local conditions should be indicated.

- Estimates of error must be stated if available.

- Available raw data should be stored in archive files for access on request.

- Sketches or pictures should be stored as hard copies and/or as picture files in a commonly accessible format.

- Data sources should be clearly identified and acknowledged.

Availability of review copies of the revised TN6 "Reporting format for the measurement of air infiltration in buildings". Papers presented at the workshop are abstracted in AIRBASE and will be available through the AIVC's library services.

11th Annual Conference

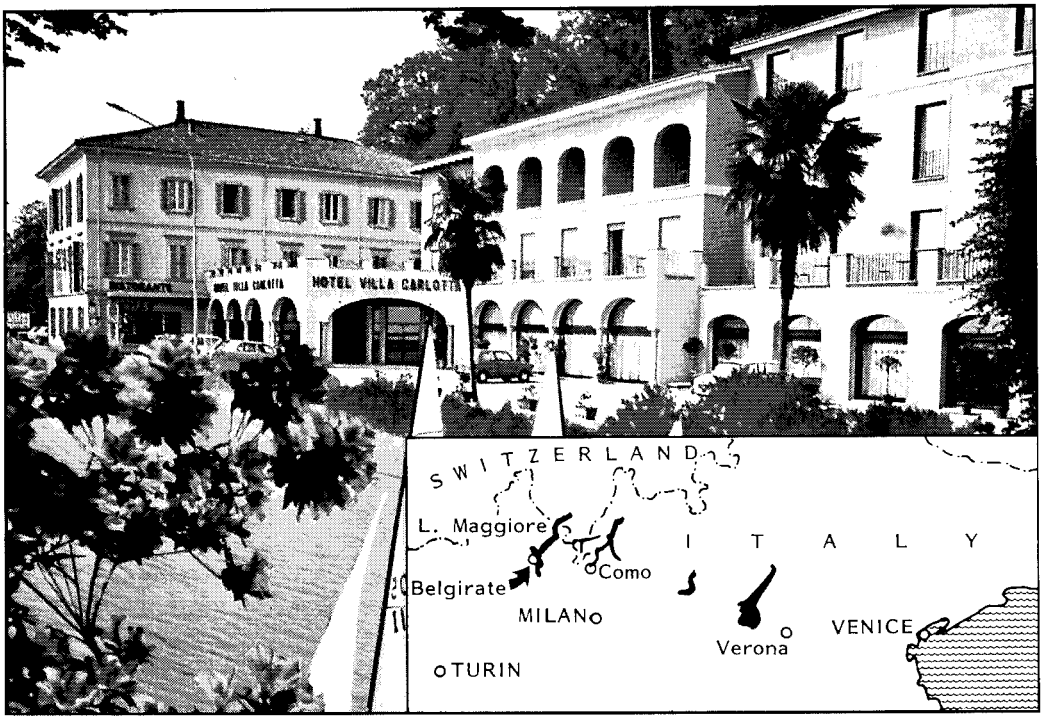
Ventilation System Performance

Date: Tuesday, 18th September - Friday, 21st September, 1990

Venue: Hotel Villa Carlotta, Belgirate, Lake Maggiore, Italy

As buildings are constructed to increasing levels of thermal performence, air exchange will eventually become the dominant source of building heat loss. However, an inadequate supply of fresh air and poor air distribution will result in high levels of indoor air pollution, odours and discomfort. Thus the proper provision of ventilation is essential if energy reductions are to be achieved without detriment to the indoor environment.

The purpose of the Air Infiltration and Ventilation Centre's 11th Annual Conference is to focus on the performance of new ventilationn technology. Special attention is devoted to case studies and to the implementation of new techniques in the field. Emphasis is also given to measurement techniques, monitoring and calculation methods. Buildings covered by the conference programme include dwellings, commercial offices, industrial buildings and schools. It is intended that the subject coverage should appeal to practitioners, researchers and others who need to understand the problems associated with ventilation technology.



Belgirate is located on the west side of Lake Maggiore, Northern Italy, near to the Swiss border. The nearest airports are Milan's Malpensa, approximately 20 km distance, and Linate. Full instructions on reaching the Conference venue will be forwarded with registration confirmation.

Registration is inclusive of accommodation and meals from lunch on Tuesday, 18th September to lunch on Friday, 21st September, 1990 (3 nights). The full registration fee will be £425 (single occupancy) and £395 (shared occupancy) which is reduced to £375 (single occupancy £345 (shared occupancy for registration fees received before 31st July, 1990.

11th Annual Conference

Ventilation System Performance

Programme

TUESDAY 18 SEPTEMBER

13.00 Arrival and Lunch

SESSION 1 Chairman: Marco Masoero (Italy)

14.00 Opening and Keynote Presentation

Intelligent Buildings: Innovative Technics for the Environment. *R Seyer and L Trepte (FRG)*

Indoor Air Quality in "Buildings of the Year" Max Productivity - Minimum of Complaints. *G Flatheim (Norway)*

Indoor Air Quality Guide for Property Managers in Office Buildings. *C Y Shaw, F Vaculik, D Patton, G M Comeau (Canada)*

Demand Controlled Systems for the Future Dwelling-houses. *M Luoma (Finland)*

The Development and Performance of a Cost Effective Mechanical Ventilation System for Mild Climates. *J P Lilly (UK)*

Tests of Localized Ventilation Systems in a New Controlled Environment Chamber. *E A Arens, F S Bauman (USA)*

18.00 End of Session 1

WEDNESDAY 19 SEPTEMBER

SESSION 2 Display Presentations - Chairman: Max Sherman (USA)

08.30-09.30 Introduction of Displays

09.30 For Man-Machine-Interface for the Air Exchange Measurement System Multi-Cat. *R Rabenstein, F D Heidt (FRG)*

The MATE-system: a multi-purpose measurement system for a detailed on site evaluation of the performances of ventilation systems. *P Wouters, L Vandaele, R Bossicard, P Voordecker (Belgium)*

An Automated Apparatus for Air Infiltration Measurements with Tracer Gases: Some Case Studies. *M Cali, R Borchiellini (Italy)*

Comparison of Tracer-Gas Methods for Measuring Air Flows in Two-Zone Buildings. *F D Heidt, R Rabenstein, G Scheppers (FRG)*

Experimental Validation of a Single Gas Tracer Technique for Identifying Airflows and Effective Volumes in a Multizone System. *P J O'Neill, R R Crawford (USA)*

Measurement of Air Flow in HVAC Systems Using Tracer Gas Techniques. *S B Riffat, M Holmes (UK)*

Airflows Measurements Using the Theory of the "Inverse Ill-Conditioned Problems" *M Cali, R Borchiellini, P Coppa (Italy)*

Ventilation Efficiency Assessment in Residential Buildings. *D Bienfait (France)*

Structure of Models for the Prediction of Air Flow and Contaminant Dispersal in Buildings. *R A Grot (USA)*

Effect of Wind Pressure Fluctuations on Air Movements Inside Buildings. *D Bienfait, R Mounajed, J Riberon (France)*

A Predictive Model for Robust Natural Ventilation *D K Alexander (UK)*

Interaction between Air Infiltration and Combustion Appliances *G Fracastoro, M Masoero, E Mazza (Italy)*

11.00 Discussion

12.30 Lunch

SESSION 3 Display Presentations -

Chairman: Willem de Gids (Netherlands)

14.00-15.00 Introduction of Displays

15.00 Numerical and Experimental Study on Flow and Diffusion Field in Room. *S Muracami, S Kato (Japan)*

Air Curtains for Infiltration Control - A Computational Fluid Dynamics Analysis. *J K W Lam, K G Ruddick, G E Whittle (UK)*

Calculation of the Air Flow Pattern in a Proposed New European Test Chamber for Radiators. *A Huber (Switzerland)*

The Controlled Ventilation Test Room of the University of Basilicata. *G Fracastoro, E Nino, G Coretti (Italy)*

Ventilating Systems and Removal of Particles. *R Schwab, E Mayer (FRG)*

Building Performance and Ventilation System. *W Braun (Switzerland)*

Two Directional Air Movements in Stairwells. *R Edwards, C Irwin (UK)*

Air Flow Through Building Slits and Components. *B A Fleury, A Y Gadilhe (France)*

Air Infiltration Through Building Room Partitions. *T Trojanowski (Poland)*

Air Change Rate and Airtightness in Buildings

Edited by M H Sherman

ASTM, 1916 Race Street, Philadelphia, PA 19103, USA,1990

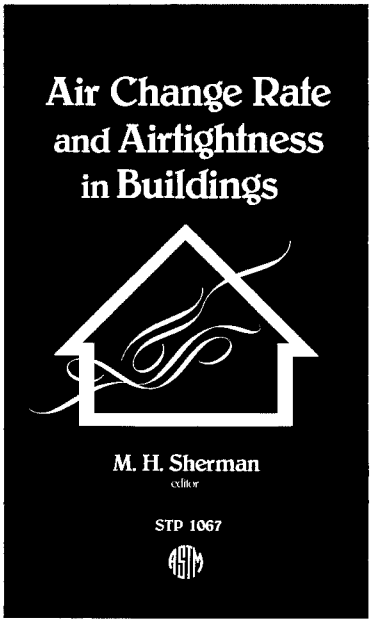
This publication contains papers presented at the symposium of the same name held in Atlanta, Georgia on 16-17 April 1989. The symposium was sponsored by ASTM Committee E-6 on Performance of Building Constructions, and its Subcommittee E06.41 on Infiltration Performances. M H Sherman, Lawrence Berkeley Laboratory, presided as symposium chairman and was editor of this publication.

Air infiltration touches on many topics in building research, not the least of which include energy, indoor air quality, and human comfort. Most residential buildings are ventilated primarily by air infiltration, and over a third of the space conditioning energy requirements can be typically attributed to it. The desire to provide adequate ventilation at minimum energy cost, combined with the complex nature of the physical processes involved in air infiltration, has effected the continuing interest in the topic.

Like the 1978 ASTM symposium, "Air Change Rate and Infiltration Measurements", the current symposium contains information on state-of-the-art techniques for measuring air change rates. In the intervening decade novel techniques for measuring more complex phenomena have been developed. Papers by Axley and Persily describe some simplified methods for making single-zone air change rate estimates from tracer gas measurements: the Fortmann and Harrje papers deal with the more complex multizone tracer techniques.

Similarly, airtightness measurement techniques have also developed since 1978. Hayakawa and Shaw describe techniques for measuring the airtightness of large single-zone buildings. Brennan and Modera discuss various techniques for making these leakage measurements in a multizone environment. Because of the relative ease and invariability of making airtightness measurements compared to tracer gas testing, far more tightness tests are done. Ek, Love, and Perera use pressurization techniques to make airtightness measurements in buildings from manufactured housing to row housing to offices.

Like the 1984 symposium, "Measured Air Leakage of Buildings", many of the papers in this symposium contained measured data on either airtightness or air change rates, some from large datasets. All of the datasets serve to shed light on various aspects of air infiltration, but papers by Hadley and Parker, which refer to the large database of data being accrued in the Pacific Northwest, may be the most notable. The Northwest Residential Infiltration Survey (NORIS) may represent the first statistically justifiable dataset on both airtightness and ventilation.



A major thrust of this symposium, which was lacking in the other two, was to consider the error associated with making field measurements using various techniques. Harrje and Shaw use multiple techniques to measure the same quantity and compare the results. In this field, for which primary standards are lacking, such intercomparisons are the best - perhaps the only - way to estimate the absolute accuracy of some techniques. Charlesworth, Nantka, Tanribilir, and Yoshino all discuss the comparison of different, but related, measured quantities.

Many factors can cause error in a measurement of either airtightness or air change rate. These errors can arise because of instrument error, inappropriate choice of analysis technique, or poor measurement technique. Flanders and Kvisgaard found that occupancy can have very significant effects on the results of air change rate measurements - both on the tracer gas measurement itself and on the interpretation of the result. Due to the nonlinear nature of both the physical processes and some of the analysis techniques, there can be a strong coupling between the precision (normally associated with random errors) and accuracy (normally associated with systematic errors). Lagus and Modera use simulation tools to estimate errors in tracer gas and pressurization tests, respectively, due to factors not taken into account in normal analyses. (from author's overview)

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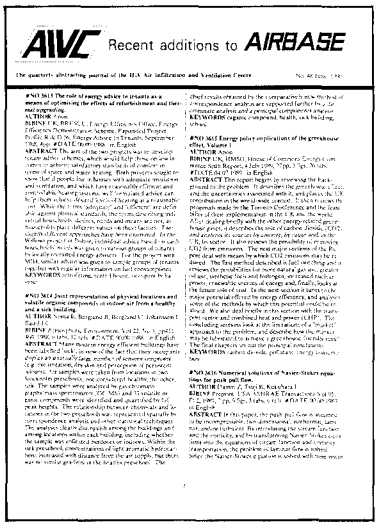
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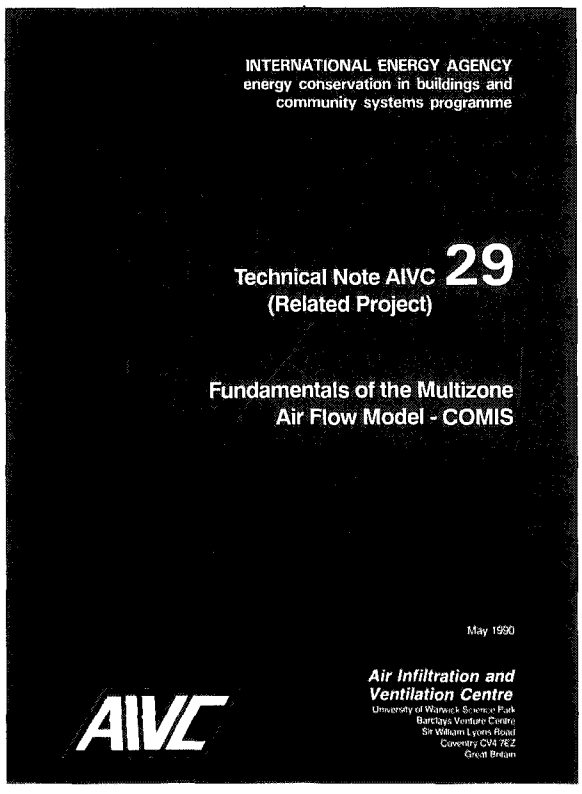
The June edition of Recent Additions to *AIRBASE* is a double length publication, containing approximately 250 records, including a section devoted particularly to papers on the subject of "air flow". With its subject key and detailed abstracts, Recent Additions is a valuable addition to your resources every quarter.

Fundamentals of the Multizone Air Flow Model COMIS

Technical Note AIVC 29 (Related Project)

May 1990

The COMIS workshop (Conjunction of Multizone Infiltration Specialists) was a joint research effort to develop a multizone infiltration model. This workshop (October 1988 - September 1989) was hosted by the Energy Performance of Buildings Group at Lawrence Berkeley Laboratory's Applied Science Division. The task of the workshop was to develop a detailed multizone infiltration program taking crack flow, HVAC systems, single-sided ventilation and transport mechanism through large openings into account. This work was accomplished not by investigating into numerical description of physical phenomena but by reviewing the literature for the best suitable algorithm. The numerical description of physical phenomena is clearly a task of IEA Annex 20 "Air Flow Patterns in Buildings", which will be finished in September 1991. Multigas tracer measurements and wind tunnel data will be used to check the model. The agenda integrated all participants' contributions into a single model containing a large library of modules. The user-friendly program is aimed at researchers and building professionals. The COMIS *Fundamentals* contains an overview about infiltration modelling as well as the physics and the mathematics behind the COMIS model.



Forthcoming Conferences

Room Vent 90 Second International Conference Engineering Aero and Thermodynamics of Ventilated Rooms

June 13-15, 1990, Oslo, Norway

Further details from:

Room Vent, c/o Norsk VVS Teknisk Forening, PO Box 5042 Maj, N-0301 Oslo 3, Norway Tel: 47 2 60 13 90

FITAT International Symposium

16-18 July 16-18, 1990, Lyon, France

Further details from:

FITAT, 34 rue de la Charité, 69002 Lyon, France Tel: 33 72 40 23 95

The 5th International Conference on Indoor Air Quality and Climate

July 29 - August 3, 1990, Metro Toronto Convention Centre, Toronto, Canada

Further details from:

Indoor Air 90 Centre for Indoor Air Quality Research, University of Toronto, 223 College Street, Toronto, Ontario, Canada M5T 1R4 Tel: 416) 978 8605

ACEEE 1990 Summer Study on Energy Efficiency in Buildings

August 26 - September 1, 1990, Pacific Grove, California, USA

Further details from:

Ed Vine, Building 90H, Lawrence Berkeley Laboratory, 1 Cyclotron Road, Berkeley, CA 94720, USA Tel: (415) 486 7478

Energy, Moisture, Climate in Buildings

September 3-6, 1990, Rotterdam, The Netherlands

Further details from:

Mr G de Vries, Bouwcentrum Weena 760, P O Box 299, 3000 AG Rotterdam, The Netherlands

Ventilation System Performance

11th AIVC Conference

September 18 - 21,1990,

Hotel Villa Carlotta, Belgirate, Italy

Further details from:

Dr Martin Liddament, AIVC

Applications and Efficiency of Heat Pump Systems in Environmentally Sensitive Times

September 18-21, 1990, Munich, Fed.Rep. of Germany

Further details from:

Lorraine Grove - Organiser, Heat Pumps Conference, BHRA, The Fluid Engineering Centre, Cranfield, Bedford MK43 0AJ, United Kingdom

Indoor Radon and Lung Cancer:Reality or Myth?

29th Hanford Symposium on Health and the Environment

October 16-19, 1990, Richland, Washington, USA

Further details from:

Fred T. Cross, Symposium Chairman, Battelle PNL, P O Box 999, Richland, WA 99352, USA Tel: (509) 375-2976

3rd International Conference on System Simulation in Buildings

December 3-5, 1990, Liège, Belgium

Further details from:

Georges Liebecq, University of Liège Laboratory of Thermodynamics, Rue Ernest Solvay, 21, B-4000 Liège, Belgium Tel: 32-41-52.01.80

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PERIODICALS

Air Infiltration Review. Quarterly newsletter containing topical and informative articles on air infiltration research and application.

Recent Additions to AIRBASE. Quarterly bulletin of abstracts added to AIRBASE, AIVC's bibliographic database.

GUIDES AND HANDBOOKS

Applications Guide 1 (1986) Liddament, M.W. 'Air Infiltration Calculation Techniques - An Applications Guide'

Applications Guide 2 (1988) Charlesworth, P.S. 'Air Exchange Rate and Airtightness Measurement Techniques - An Application Guide'

Handbook (1983) Elmroth, A. Levin, P. 'Air infiltration control in housing. A guide to international practice.'

TECHNICAL NOTES

TN 5 (1981) Allen, C. 'AIRGLOSS; Air Infiltration Glossary (English edition)'
TN 5.1 (1983), 5.2 (1984), 5.3(1985), 5.4(1988) Allen, C. 'AIRGLOSS'; Air Infiltration Glossaries (German, French, Italian and Dutch) Supplements.
TN 6 (1981) Allen,C. 'Reporting format for the measurement of air infiltration in buildings'
TN 10 (1983) Liddament, M,, Thompson, C. 'Techniques and instrumentation for the measurement of air infiltration in buildings - a brief review and annotated bibliography'
TN 11 (1983) Liddament, M., Allen, C. 'The validation and comparison of mathematical models of air infiltration'
TN 13 (1984) Allen,C. 'Wind pressure data requirements for air infiltration calculations'
TN 13.1 (1984) '1984 Wind Pressure Workshop Proceedings' .
TN 14 (1984) Thompson, C. 'A Review of Building Airtightness and Ventilation Standards'
TN 16 (1985) Allen,C. 'Leakage Distribution in Buildings'
TN 17 (1985) Parfitt, Y. 'Ventilation Strategy - A Selected Bibliography'
TN 19 (1986) Charlesworth, P. '1986 Survey of current research into air infiltration and related air quality problems in buildings'.
TN 20 (1987) 'Airborne moisture transfer: New Zealand workshop proceedings and bibliographic review'
TN 21 (1987) Liddament, M.W. 'A review and bibliography of ventilation effectiveness - definitions, measurement, design and calculation'
TN 23 (1988) Dubrul,C. 'Inhabitants' behaviour with regard to ventilation.
TN 24 (1988) 'AIVC Measurement Techniques Workshop: Proceedings and Bibliography'
TN 25 (1989) Blacknell,J. 'A subject analysis of the AIVC's bibliographic database - AIRBASE',
TN 26 (1989) Haberda,F and Trepte,L. IEA Annex IX 'Minimum ventilation rates and measures for controlling indoor air quality.
TN 27 (1990) Bassett, M. 'Infiltration and leakage paths in single family houses. A multizone infiltration case study.'
TN 28 (1990) Sutcliffe, H. 'A guide to air change efficiency.'
TN 29 (1990) Feustel, H E, et al 'Fundamentals of the multizone air flow model - COMIS.'

AIVC CONFERENCE PROCEEDINGS

1st 'Instrumentation and measuring techniques',Windsor, UK, 1980.
2nd 'Building design for minimum air infiltration', Stockholm, Sweden, 1981.
3rd 'Energy efficient domestic ventilation systems for achieving acceptable indoor air quality', London, UK, 1982.
4th 'Air infiltration reduction in existing buildings', Elm, Switzerland, 1982.
5th 'The implementation and effectiveness of air infiltration standards in buildings', Reno, USA, 1984.
6th 'Ventilation strategies and measurement techniques', Het Meerdal Centre, Netherlands, 1985.
7th 'Occupant interaction with ventilation systems' Stratford-upon-Avon, UK, 1986.
8th 'Ventilation technology - research and application', Uberlingen, West Germany, 1987.
9th 'Effective Ventilation' Ghent, Belgium, 1988
10th 'Progress and trends in air infiltration and ventilation research' Espoo, Finland, 1989
mf Proceedings of AIVC conferences numbers 1-10 are also available in microfiche form.

LITERATURE LISTS

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1) Pressurisation - infiltration correlation: 1. Models.
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9) Air infiltration in public buildings.
10) Carbon dioxide controlled ventilation.
11) Occupancy effects on air infiltration.
12) Windbreaks and shelterbelts.
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