Air Infiltration Review

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International Energy Agency — AIVC

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AIVC'S 9TH ANNUAL CONFERENCE BELGIAN SECRETARY OF STATE FOR SCIENCE POLICY PRESENTS KEYNOTE ADDRESS.

Conference Report Gent, Belgium, 12th-15th September 1988.

Martin W. Liddament, AIVC

Attendance at the Air Infiltration and Ventilation Centre's 9th Annual Conference exceeded all expectation, with approximately 100 participants from a record 15 countries making this event one of the most international of specialist conferences. The Keynote address was delivered by Mr Marcel Colla, the Belgian Secretary of State for Science Policy and concentrated on the benefits of international participation in relation to energy research and development.

The conference was divided into four presentation sessions, and two technical poster and demonstration evenings. There was also a technical visit to the Belgian Building Research Institute. The topics covered included air flow patterns, ventilation efficiency, measurement methods, ventilation techniques and case studies. Mark Bassett from the Building Research Association of New Zealand made the first presentation, which was concerned with natural air flow between roof, subflow and living spaces within dwellings. Results concentrated on air flow measurements made in five dwellings, representing contrasting construction styles, using a two gas tracer technique. This was followed by a paper presented by Pierre Nusgens of the University of Liege, Belgium, outlining an experimental analysis of air diffusion in a large agricultural building. Measurements were made in a reduced scale model in which flow patterns were evaluated for various configurations of ventilation slots and temperature differentials. Ren Anderson of the Solar Energy Research Institute in the United States introduced a short term testing method to evaluate the performance of ventilation systems with respect to the control of indoor air pollutants. He also defined two efficiency measures, displacement efficiency and removal efficiency, relating to the degree of short circuiting and the removal of indoor air pollution respectively.

Lutz Trepte of Dornier Systems GmbH, Federal Republic of Germany, considered problems relating to polluted outdoor air and the resultant strategies needed to ensure a safe internal environment. Strategies included filtration as well as the control of air exchange. The mechanisms of ventilation generated by fluctuating pressure difference were reviewed in a paper by Dr. Sahin et al of Brunel University in the United Kingdom. The results of an experimental study based on a laboratory model of flows through typical building apertures were compared with the results of theoretical analysis. The final technical paper of the first day was presented by Hans Martin Mathisen of

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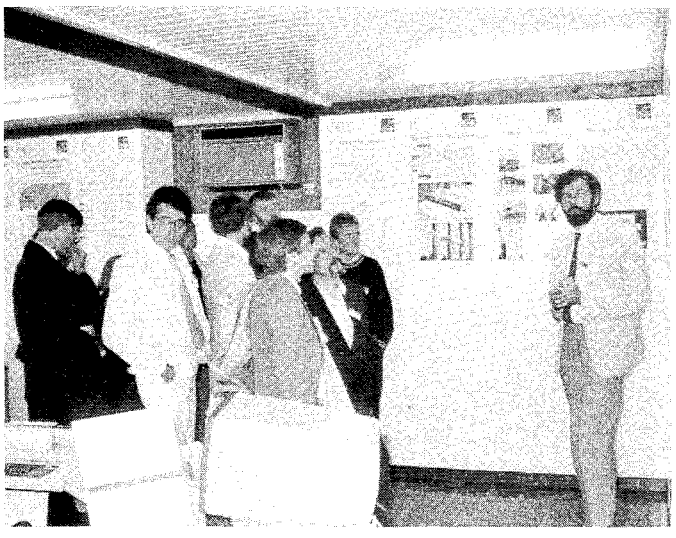
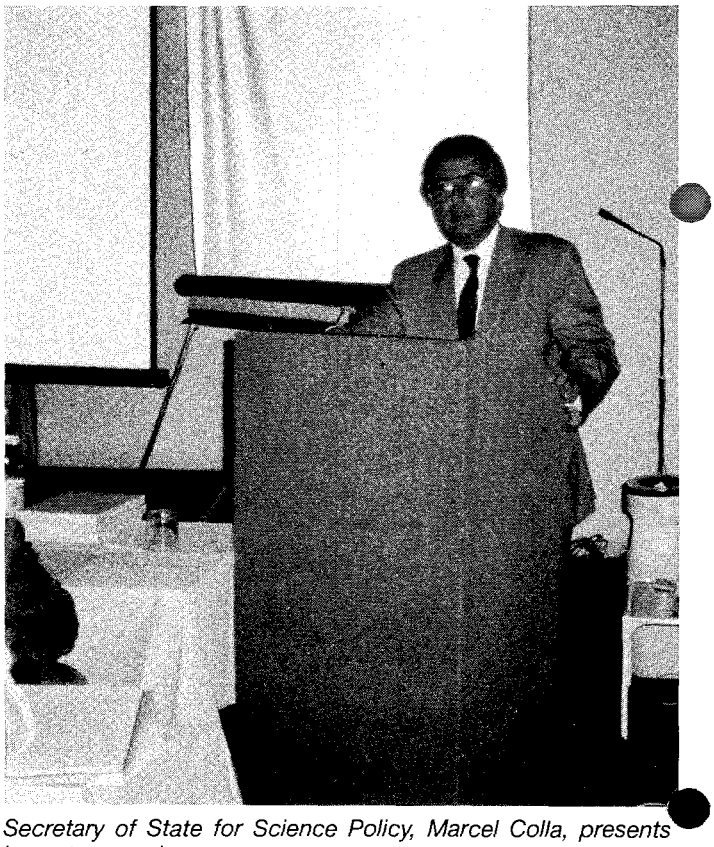
SINTEF in Norway, who reviewed both experimental and theoretical models illustrating the relationships between air flow rates, temperature and air supply device design in displacement ventilation systems.

Jim Axley from the National Bureau of Standards in the United States introduced the first paper of the second technical session. This was concerned with a description of the pulse injection tracer gas technique for measuring air flows in ducts and in single zone and multi zone buildings. It was suggested that pulse methods may provide a means to improve upon the accuracy of commonly used constant injection methods. Bill Fisk from the Lawrence Berkeley Laboratory in the United States then described commercial building ventilation measurements using multiple tracer gases. The method was used to monitor ventilation rates, air exchange efficiency, ages of air, flow rates of supply and outside air, and percent outside air in supply airstreams.



In the BBRI laboratory at Limelette.

Bjorn Kvisgaard of Bruel and Kjoer in Denmark followed by describing a 2-tracer gas constant concentration system for air flow measurements between zones. David Harrje from Princeton University in the United States described extended testing of a multi family building using constant concentration and perfluorocarbon tracer methods. The levels of air exchange in a test apartment were also compared with tracer measurements in the stairwell of the building. A paper by Magnus Herlin of the Royal institute of Technology, Sweden and Mark Modera of the Lawrence Berkeley Laboratory in the United States was introduced on the examination of the fan pressurisation technique for measuring interzonal air leakage. Special attention was given to the uncertainties associated with this technique. Results suggested that while wind induced uncertainties in the determined leakage parameters do not exceed 10% for windspeeds below 5 m/s, both pressure and flow measurement uncertainties raise leakage parameter errors by 40%. Jean-Marie Fubringer of the Ecole Polytechnique Federale, Switzerland described the use of a guarded zone pressurisation technique to measure air flow permeabilities of a multi zone building. An important objective of this technique is to establish a databank of high quality permeability measurements. The theme of air leakage between apartments was continued by Per Levin of the Royal Institute of Technology in Sweden. He described results of the simultaneous pressurisation of adjacent apartments in order to establish both leakage to the outside and the leakage between apartments. In terms of volumetric flow, the leakage between apartments was found to be very low, although as a percentage of the total leakage, measurements varied by between 17 and 36%.



Secretary of State for Science Policy, Marcel Colla, presents keynote speech.

Air Infiltration Review

Editor : Janet Blacknell
Technical Editor : Peter Charlesworth

Air Infiltration Review has a quarterly circulation of 3,500 copies and is currently distributed to organisations in 39 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.

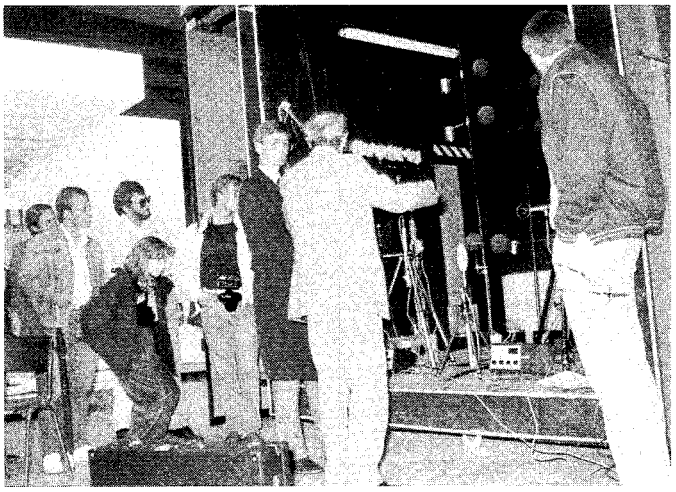
Conclusions and opinions expressed in contributions to Air Infiltration Review represent the author(s)' own views, and not necessarily those of the Air Infiltration and Ventilation Centre.

The final two technical sessions were devoted to specific aspects of ventilation strategy and control. Marco Masoero of the Politecnico di Torino, Italy analysed the infiltration heat losses due to heating appliances taking into account the fluid dynamic interaction between boiler, chimney and building. Inside pressure and air flows across the envelope, through the boiler, the draft diverter and the chimney were calculated by means of a steady state model. Mark Riley from Energy Mines and Resources, Canada discussed formaldehyde levels in Canadian R2000 homes. These homes have balanced ventilation with heat recovery and initial levels of formaldehyde averaged 0.069 ppm. This has decreased to 0.045 ppm following changes to air flow distribution requirements. There was no evidence that the increasing age of R2000 homes had any significant effect on the decline of formaldehyde concentrations. Willem de Gids from MT-TNO in the Netherlands also discussed domestic pollution by considering recirculation of air in dwellings. Current Dutch standards require that fresh outdoor air is required for bedrooms, while the bathroom, kitchen, WC and living room can be ventilated with air from other rooms. Field measurements in typical homes show that leeward sided bedrooms can receive contaminated air, however, simple measures in air heating installations can improve air flow patterns. Additionally, the use of effective window opening can minimise contaminant levels in dwellings. Aubrie Baillie from the University of Surrey in the United Kingdom described research into the occupant's perspective of effective ventilation. Environmental comfort ratings were derived from the comments of a total of 169 occupants of two air conditioned and three naturally ventilated office buildings. The perception of occupants was that the air conditioned buildings were less satisfactory. However the differences, although statistically significant, were small in magnitude. Marianna Luoma of the Technical Research Centre of Finland looked into a ventilation concept for future dwellings. While this would be based on mechanical systems, it would respond to real living functions and would thus be capable of operating at variable air flow rates. A modular approach is also envisaged in which a versatile range of alternatives can be developed from a small set of standard components.

Participants of the AIVC Conference assemble for the official reception at Gent Town Hall.

Moving from future systems, Richard Walker of the Building Research in the United Kingdom returned to the concept of passive systems for summertime ventilation. Natural ventilation for a court-room based on an underfloor duct system and controllable roof level vents was described. The sizing and control of the duct and vent system was based on a statistical analysis of local weather data. Willigert Raatschen from Dornier Systems GmbH in the Federal Republic of Germany presented an analysis of sensors for use in demand controlled ventilation systems. Such systems have considerable potential in the energy efficient control of ventilation and in preventing serious air quality problems. Typical contaminant sensors included humidity, carbon dioxide, fumes and particulates (tobacco smoke).

As a case study linking need for ventilation in the control of fumes, Mike Holmes and Tudor Salusbury of Ove Arup and Partners in the United Kingdom explained how current theoretical approaches had been used in the design of a large bus terminal. The design, based on mechanical ventilation, took into account the need to ensure adequate air quality in an enclosed area. The final paper was presented by Peter Wouters of the Belgian Building Research Institute. Peter gave an account of the ventilation approaches in Belgium and provided results on the airtightness testing of various buildings and building components. He also outlined some of the ventilation related problems occuring in Belgium especially in relation to condensation and mould growth. Other problems related to odour, comfort conditions and radon.



In the great hall at Limelette: director Jozef Uyttenbroeck explains the operation of various measurement instruments.

The technical poster evenings provided an excellent opportunity for more detailed discussion and the standard of these evenings was exceptionally high. The exceptional attendance and interest at these sessions illustrated the value of this type of presentation.

Topics included:

- quantitative visualisation of air streams
- diffusers for displacement ventilation
- air heating systems
- passive ventilation
- multi tracer gas systems
- constant concentration tracer gas methods
- ventilation characteristics of a suspended floor
- numerical simulation of turbulent air flows
- contaminant dispersal
- buoyancy driven flow
- air infiltration in multizone buildings
- influence of topography on wind
- influence of controlled natural ventilation on radon
- energy and condensation
- influence of ventilation strategy on humidity
- airborne moisture transfer in dwellings
- ventilation methods in dwellings
- performance of ventilation systems
- influence of convective heat sources on air flow
- influence of ventilation on contaminant levels in office buildings
- mathematical modelling of building ventilation systems.

Reception at Gent Town Hall: AIVC representative Steve Irving (left) talks with Mr Marcel Colla.

Each poster is fully described in the conference proceedings.

The technical visit to the Belgian Building Research Institute attracted considerable interest and was attended by almost all of the conference participants. Despite the large number present the tour was well organised and encompassed all aspects of building energy research. Among the displays there was a demonstration of pressurisation and tracer gas testing and presentations on airflow studies and research into passive solar heating.

AIVC delegates visit the BBRI testing station at Limelette.

A final summing up session provided opportunity for additional discussion and thoughts. This was very much concerned with the definition of ventilation efficiency and the purpose of such definitions in explaining the complex problems of contaminant and air flow. Other topics discussed included the merits of displacement ventilation, which has now become popular in parts of Scandinavia, experimental and measurement techniques, standards, new construction approaches and recommendations for future activities of the AIVC.

The full proceedings of the conference including discussion notes are available direct from the AIVC, price £30 sterling inclusive of postage and packing.

AIVC 9TH ANNUAL CONFERENCE KEYNOTE ADDRESS

Mr. Marcel Colla
Secretary of State for Science Policy, Belgium

It is with pleasure that I have accepted the offer to close today the first working session of the 9th Conference of the Air Infiltration and Ventilation Centre of the International Energy Agency. As Secretary of State, responsible for Science Policy, it is also an honour to have the opportunity to do so, let's admit it in front of a highly scientific audience. It is indeed important that Policy makers and Scientists meet each other regularly.

I don't have to convince you, I suppose, of the importance of Air Infiltration and Ventilation in the energy balance of dwellings in particular and therefore in the overall energy budget of our countries. The creation of your Centre, the growing interest for your work and the discussions during Conference prove this sufficiently.

It is however a good opportunity to stress the role your Centre has played in our own national efforts on this subject. As you probably know, the National R.D. Programme on Energy, created and directed by my Department since 1975, has recognised at the start of its third phase (1982-1987) the important scientific effort that was necessary to cover the gap existing at that time in our knowledge on the subject. In the programme an important budget was therefore allocated to ventilation research, at the Belgian Building Research Institute.

More important however, to cover the gap, was the step to join the Air Infiltration and Ventilation Centre in 1983. It permitted almost immediately to start our own research in the best conditions, taking advantage especially of the experience of the Centre in measurement — and evaluation methodologies and in calculation tools. Once again this was a good example, for a small country like Belgium, of the importance of international research collaboration in which I strongly believe. Therefore I think we have to continue to support this kind of research, be it in the framework of the EC and/or the International Energy Agency : scientist must travel, not only for pleasure but to exchange ideas and methodologies, confrontate theories and share results to the benefit of the entire community.

This ventilation area also shows the necessity of multi-disciplinarity; too often scientists isolate themselves and their results in the mist of their own vocabulary.

Ventilation is an area related to many others, which may not be neglected by the technicians. Belgium was therefore very happy to have taken, a few years ago, the leadership of an I.E.A. task in that field ("Human behaviour and ventilation"). Although difficult in starting and working out, this research came recently to an end but has shown very interesting results. It was maybe one of our most valuable contributions to the area which interests you.

In the recent past, the decreasing of oil prices has been for Belgium, like other countries, an easy alibi to cut down the research efforts in the energy conservation field. I regret that only a few activities have been saved from this new storm. I am happy today that the ventilation related research was one of them, that our contribution to I.E.A. has been preserved and that even some new actions were undertaken as proves our recent commitment to a new I.E.A. task on "Air flow patterns in buildings". However, I believe that this minimum effort must be extended again, to preserve our evaluation and research capacities in the field, to offer a minimum continuity, which is indispensable in all research work and especially in research that underlines policymaking. I therefore have the intention to convince my colleagues to restart a new national effort in energy-research. We will of course take advantage of the results of the National R.D. Programme on Energy and take profit of the experience that has been built up. It finally means that a new effort must be imbedded in existing and new demands, as for example the environment requirements. Energy and energy research is not something that stands on its own; it must be part of our global reflexion on building construction, on industrial productivity, and on new social developments. It means that this research must be, more than in the past, directed to policymaking work: we cannot prepare a decision on the construction of a new electricity plant or on the volume of a gas agreement if we don't know how much the building and industry sectors will consume in the next decades and therefore we need your technological input : what kind of solutions will you offer us for, let us say, the ventilation of the building of the year 2000, or for the rehabilitation of the existing building stock. And important : what will your solution cost, what will it save, how will it be accepted by the public and the building sector,... So many interesting questions where science and political decision have to meet. In that way, I will continue to assimilate your work because I believe it is vital, because I believe that Rational Use of Energy is a fundamental element for our energy policy.

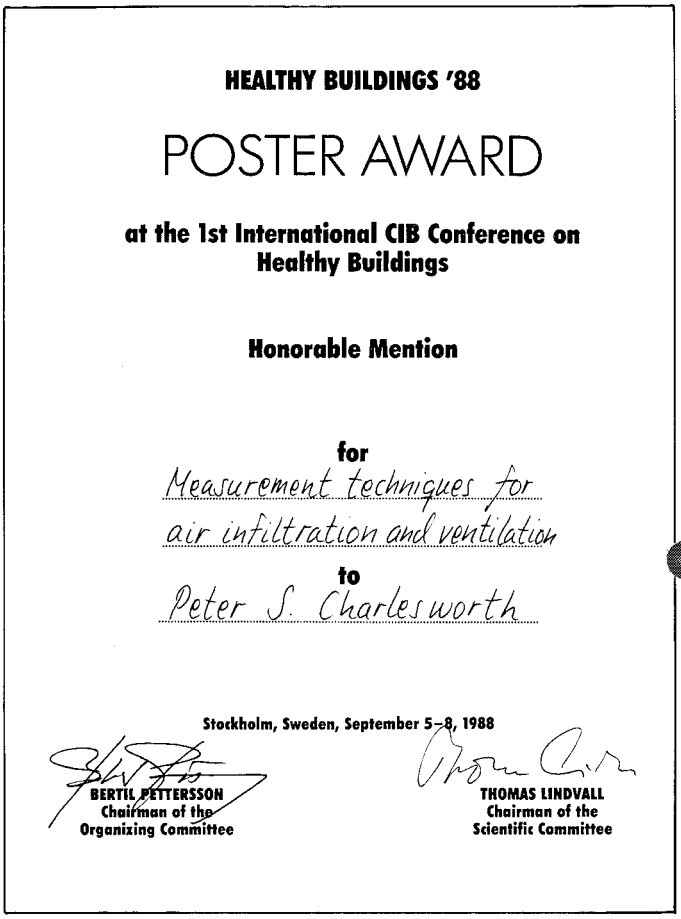
Since the oil prices decreased recently, private energy consumption for building heating has risen again significantly: people have rediscovered, I'm afraid an energy consuming behaviour: too little was invested in structural modifications, in the improvement of the heating systems, in the definition and setting-up of better ventilation strategies : it shows the weakness of our effort but also the urgent necessity to prepare the future in a more efficient way. Therefore, we must preserve and enlarge our scientific potential and our evaluation capacity of the past and the future. Therefore also, we must multiply our effort of dissemination of the research work. The public, the industrial sectors, the policymakers ask for an objective view on the problems, based on scientific work, especially in the energy field. It is our role to continue to support the realisation and dissemination of objective and accurate information. Your Air Infiltration and Ventilation Centre is a good example of how it can be done : sampling and analysing the available research efforts, publishing reports, discussing the research in highly scientific congresses like this one : the response to all these steps shows the usefulness of the process and the efficiency of the way you do it. Let my short speech therefore be a message of support to the work of this Conference and to the efforts you all undertake.

I thank you for your attention.

AWARD FOR SENIOR SCIENTIST AT HEALTHY BUILDINGS CONFERENCE

Dr. Peter Charlesworth of the AIVC attended "Healthy Buildings '88", the CIB Conference in Stockholm, Sweden on September 5-8, 1988 and presented his poster entitled "Measurement techniques for air infiltration and ventilation", for which he received a commendation. His full paper is reproduced below.

The proceedings are available in four volumes from the Swedish Council for Building Research in Stockholm.



HEALTHY BUILDINGS '88

POSTER AWARD

at the 1st International CIB Conference on Healthy Buildings

Honorable Mention

for

Measurement techniques for air infiltration and ventilation

to

Peter S. Charlesworth

Stockholm, Sweden, September 5–8, 1988

BERTIL PETTERSSON
Chairman of the Organizing Committee

THOMAS LINDVALL
Chairman of the Scientific Committee

Measurement Techniques for Air Infiltration and Ventilation

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Abstract

The provision of an adequate supply of uncontaminated outdoor air is an important factor in maintaining a comfortable internal environment within a building. Dilution by incoming air is one means by which pollutants from sources in the building can be maintained within tolerable concentration limits. Therefore air infiltration and ventilation must be taken into account when considering the indoor air quality of any internal environment. Three important parameters can be identified : ventilation rate, interzonal air flow and air leakage characteristics. The importance of these parameters is discussed and various techniques for their measurement are described. Descriptions will be necessarily brief and further information about measurement techniques may be obtained from the Air Infiltration and Ventilation Centre.

Pollution Dilution

The concentration of a contaminant in a ventilated enclosure is given, at any instant in time, by the continuity equation :

$$\underbrace{\text{Vol}\times\frac{dC_{in}}{dt}}_{\text{Term 1}} + \underbrace{mQ\,(C_{ext} - C_{in})}_{\text{Term 2}} = \underbrace{(S - \lambda)}_{\text{Term 3}} \quad \text{(mass/time)} \quad (1)$$

where

- Vol = volume of enclosure (m^3)
- λ = rate of chemical or physical decay of pollutant (mass/s)
- m = empirical mixing factor (varies from 0 to 1, m=1 is equivalent to perfect mixing)
- C_{in} = internal concentration of pollutant (mass/m^3)
- C_{ext} = external concentration of pollutant (mass/m^3)
- Q = ventilation rate (m^3/s)
- S = total rate of emission of pollutant (from all sources)

For indoor air quality studies Equation (1) must be solved in terms of the internal concentration of the pollutant.

Importance of Ventilation Rate

In simple cases some terms in Equation (1) may be eliminated. If the emission rate of the pollutant is constant (e.g as is assumed with formaldehyde) and the ventilation rate is steady then Term (1) of Equation (1) will tend to zero and the equilibrium concentration will be given by :

$$(C_{int} - C_{ext}) = \frac{(S - \lambda)}{mQ} \quad (2)$$

With formaldehyde there will be no physical or chemical degradation, neither will there be an external component. Also if perfect mixing is assumed (m = 1) the internal concentration becomes :

$$C_{in} = \frac{S}{Q} \quad (3)$$

Therefore if ventilation rates and pollution emission levels are known, then the internal concentration of potentially harmful pollutants may be evaluated. This simple example illustrates the importance of ventilation rate measurements in the assessment of indoor air quality in the built environment.

Measurement of Ventilation Rate

The direct measurement of ventilation rate usually involves the release and monitoring of a suitable non-toxic tracer gas within the building enclosure. By treating the building as a single perfectly mixed space a continuity equation similar to Equation (1) can be developed.

$$V \frac{dC}{dt} = Q[C_e - C_{(t)}] + F \quad (4)$$

where

V = effective volume of enclosure, m^3
Q = air flow through enclosure, m^3s^{-1}
C_e = external concentration of tracer gas
$C_{(t)}$ = average internal concentration of tracer gas at time, t
F = production rate of tracer from all sources within enclosure

Decay Rate Method

The most straightforward method of solving the continuity equation is to make a one time injection of tracer gas into the enclosure. Following the cessation of gas injection, assuming that the outdoor concentration of tracer gas is negligible, and that there are no incidental sources of tracer within the building. The variation of tracer concentration with time is given by :

$$C_{(t)} = C_{(o)} e^{-\frac{Q}{V}t} \quad (5)$$

where

$C_{(o)}$ = concentration of tracer gas at time, t=0
$\frac{Q}{V}$ = N = air change rate, h^{-1}

Hence by measuring the tracer concentration with time the air change rate, N, can be evaluated. Air change rate is the volumetric rate of which air enters or leaves a space divided by the volume of the space. Therefore by measuring the volume of the building the ventilation, rate, a, can be evaluated from Equation (5). Measurements of tracer can be made directly on site (see Figure 1) or air samples can be taken from the buildings at intervals and analysed later in the laboratory (see Figure 2). Whichever way concentration data is obtained the simplest method of evaluating the air change rate is to plot the log of concentration against time and the air change rate is then the negative slope of the plotted line.

Constant Emission Rate Method

A second approach to the solution of the continuity is to set the source term F not at zero but at some known fixed valve. At equilibrium Equation 6 simplifies to :

$$Q = \frac{F}{C_{(t)}} \quad (6)$$

where

Q = ventilation rate
F = tracer production rate
$C_{(t)}$ = tracer concentration

Therefore the ventilation rate can be evaluated directly from the tracer injection rate and concentration data. The equipment required to perform this type of measurement is similar to that used for the decay rate method except that as the tracer is continuously injected some means of evaluating the tracer flow rate must be provided (see Figure 3).

Also as this method allows continuous measurement of ventilation rate to be made a microcomputer is often used to evaluate and store the results.

A second practical method of utilising constant emission rate theory is known as passive sampling. Here a small tube of liquid is placed in the building, this emits tracer gas at a constant rate through a porous plug. A sample device collects tracer by the process of passive diffusion. Both emitter and sampler are left in the building over a period of time and when removed the amount of tracer collected by the sampler is evaluated using laboratory based equipment. Hence the average ventilation rate can be estimated

$$\overline{Q} \simeq \frac{F}{\overline{C}} \quad (7)$$

Where

$\overline{Q}$ = average ventilation rate
$\overline{C}$ = average tracer concentration

The approximation is given in Equation (8) because it can be shown that the reciprocal of an average concentration, which is the quantity that the passive sampler determines is close but not equal to the average of reciprocal concentrations.

Constant Concentration Method

A third technique for evaluating the ventilation rate involves reducing the continuity equation (Equation 4) to it's simplest form. By maintaining the tracer gas concentration level at a constant value within the enclosure, the continuity equation becomes :

$$Q = \frac{F_{(t)}}{C} \quad (8)$$

Where

Q = ventilation rate

$F_{(t)}$ = tracer production rate at time t

C = maintained concentration of tracer

This is identical to the expression for the constant emission rate method except that it is the tracer production rate which is varied to maintain a constant concentration.

The constant concentration method requires sophisticated equipment and control mechanisms. The measurement system varies the rate of tracer injection to regulate the concentration in the enclosure. This is known as a closed loop operation. The system feeds back information about the measured concentration in the enclosure in order to adjust the injection rate which maintains the concentration at the required level. The known injection rate is then used to evaluate the air change rate. Fully automated instrument packages incorporating a microcomputer have been designed for this purpose (see figure 4). Using these packages, the concentration can be kept constant in several zones of the test building thus enabling the ventilation rate of individual rooms to be evaluated.

Pollution Migration

The measurement of ventilation rate may, in many cases, be adequate to give an indication of indoor air quality problems within a building. However, the pollutant continuity equation (Equation 1) assumes that the pollutant and ventilation air are uniformly mixed throughout the measured enclosure. Such conditions may not prevail in practice. Pollution sources are often located at a particular point in large interior spaces or confined to an individual room within a building. Thus the pollution from a particular source may not be evenly distributed throughout the ventilated space.

As a consequence of internal air movement pollution migration may occur and this can be detrimental to either fabric or occupants of the building. Specific examples of this would be hospitals, where the transport of odours and germs must be kept to a minimum and houses, where the migration of moisture from production zones such as kitchens to unheated areas such as bedrooms or attics could cause condensation problems. Therefore, in order to gain complete understanding of the ventilation behaviour of a building it is necessary to measure the rate of air exchange between the various internal spaces of the structure.

A simple technique may be employed to determine the migration path of a pollutant. An inert tracer gas is released in one part of a building (representing the pollutant source), and determination devices are set up in other areas of the enclosure. If the tracer is detected then this may provide qualitative information about air flow patterns and pollution migration. A slightly more sophisticated approach can be made. A source which emits tracer at a constant rate is placed in the building and a passive sampling device is located at the measurement point. By evaluating the amount of tracer collected over a period of time by the sampler, information about actual amounts of pollutant migrating from one point to another can be gathered.

Measurement of Interzonal Air Flow

To gain more detailed information about potential pollutant migration the actual values of the air flow rates between various zones of multi-compartment buildings. The measurement of these air flows also requires tracer gas techniques. However, because of the complex nature of the air flow patterns it is usual to utilise multiple tracer gas methods to perform this type of measurement.

Three of the techniques discussed above i.e. decay rate (site analysis), constant emission rate (passive sampling) and constant concentration have been adapted for multi-tracer gas work.

In the multi-tracer decay technique a different tracer gas is released in each zone under examination. The concentration of all tracers are examined in each zone for a period of about 10 minutes. From this concentration data the instantaneous interzonal air flows can be evaluated.

By placing a different constant emission rate tracer device in each zone and using a sampling device which can collect all the types of tracer released, the average air flow between internal spaces can be evaluated.

In the multi-tracer constant concentration method a different tracer is released in each zone and kept at a constant concentration in that zone. The concentration of all tracers is measured in all zones by evaluating these concentrations the interzonal air flow rates can be evaluated continuously.

Air Leakage Characteristics

Ventilation rate and interzonal air flows are parameters which are themselves dependent upon a variety of climatic, behavioural and constructional factors. A second basic approach in infiltration and ventilation studies is to characterise the building envelope only and then use mathematical models to predict ventilation rates and interzonal air flows under a variety of environmental and building usage conditions.

Air movement through the building envelope occurs if there is a pressure difference across it. Under normal operating conditions this pressure difference may be created by the wind, indoor/outdoor temperature or mechanical ventilation system.

In order to characterise the leakage performance of the building envelope it is necessary to determine quantitatively the relationship between the air flow through, and the pressure differential across, the leakage paths. The building envelope can be measured in its entirety or if more detail is required, individual building components or leakage paths can be examined.

Evaluation of the air leakage characteristics of a structure consists of superimposing a known artificial pressure difference across the envelope or component and measuring the flow rate through it.

Two basic methods exist. In the first, which is equally applicable to whole buildings or building components, a steady-state (DC) pressure differential is created across the building envelope. This is created by a fan and the flow rate through the fan is related to the pressure across the building fabric.

In the second, a piston is used to create a continuous sinusoidal change of a building's internal volume. In turn this creates a time-varying pressure difference across the building envelope, this can be distinguished from naturally occurring pressure fluctuations.

By measuring the amplitude of the pressure response inside the building, and the phase relationship between the pressure and the velocity of the piston the air flow through the envelope can be evaluated. Given this computed air flow

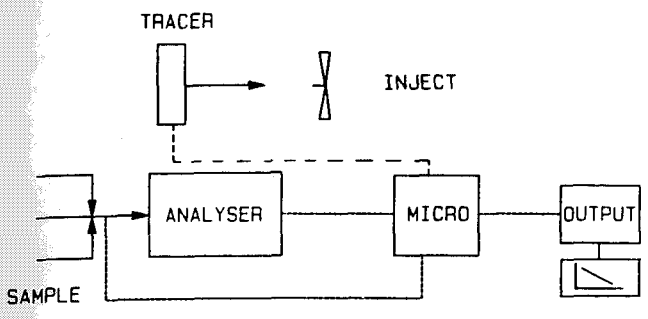

Fig. 1. Decay rate site analysis equipment

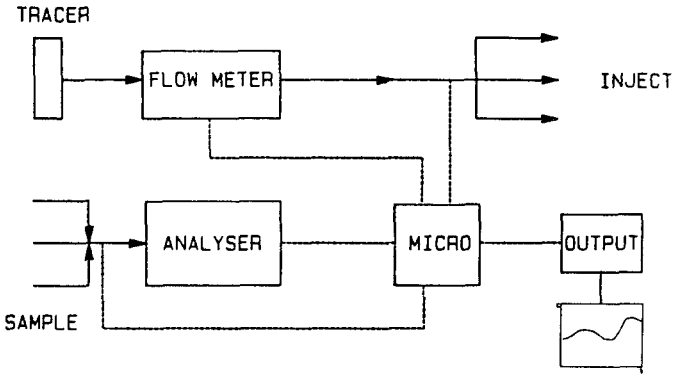

Fig. 3. Constant emission rate site analysis equipment

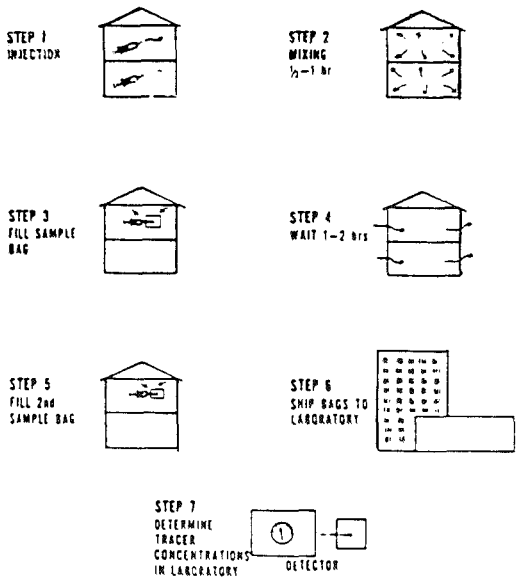

Fig. 2. Decay rate grab sample sequence

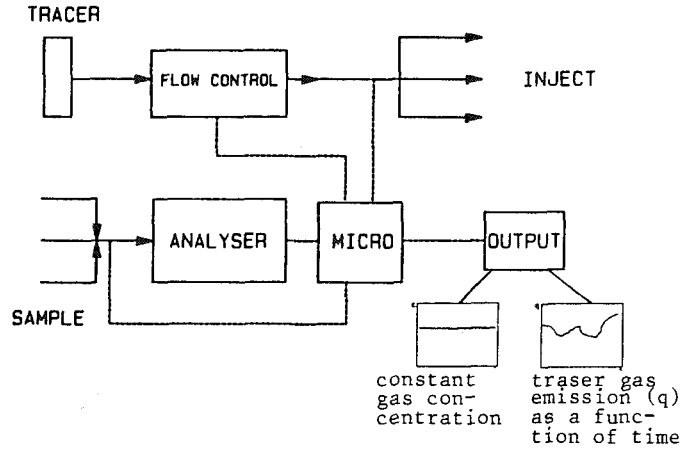

Fig. 4. Constant concentration analysis equipment

and the measured pressure differential the leakage performance of the building envelope can be determined. This method may not be suitable for the examination of some building components,

Conclusion

This paper has discussed, in terms of indoor air quality studies, the importance of :

Ventilation rate
Interzonal air flows
Air leakage characteristics

The techniques used to evaluate these parameters have been examined. Measurement techniques are the fundamental means of acquiring a greater understanding of air infiltration and ventilation in that they enable primary data to be obtained from the examination of existing structures. This account of measurement techniques is neither detailed nor exhaustive. Further information about measurement techniques for air infiltration and ventilation can be found in:

"A Guide to Air Exchange Rates and Airtightness Measurement Techniques".

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A New Home for the AIVC Warwick University Science Park

As part of a major reorganisation the IEA's Air Infiltration and Ventilation Centre relocates to the University of Warwick Science Park on 1st September 1988. It continues to be operated through Oscar Faber Consulting Engineers on behalf of the International Energy Agency.

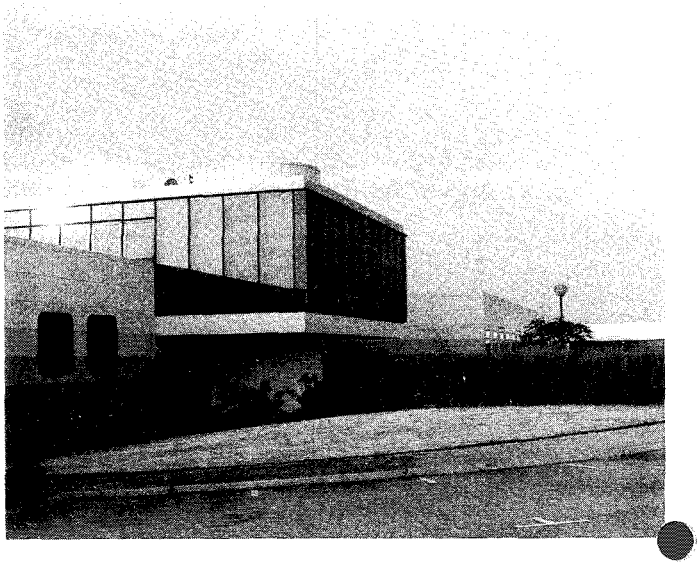
This move is seen as an essential step in increasing the technical resources of the Centre and in providing ideal facilities for attracting specialists from other countries. The Centre which began as a small jointly funded activity supported by 8 countries in 1979 has now grown considerably in stature and enters its 10th year of operation with support from a total of 13 countries.*

The AIVC offers technical support to researchers and end users engaged in the prediction and measurement of heat loss due to air exchange in buildings. It also has the task of promoting an understanding of the process of air flow and of advancing the application of energy efficient ventilation measures in both new and existing buildings. This is a vital aspect of building design, since energy use due to ventilation can account for as much as 50% or more of a buildings total space heating or cooling load. On the other hand an inadequate supply of fresh air and/or poor air distribution can cause severe indoor air quality problems.

The hub of the Centre's service is its computerised bibliographic database – AIRBASE, which is available using micro STATUS free text retrieval software. Currently the database contains approximately 3000 abstracts of technical articles related to infiltration and ventilation. In addition it contains information on current worldwide infiltration and air quality research programmes. The source articles are available from the Centre and a full international technical library service is offered to organisations in participating countries. Use of this service is running at its highest ever level, with the AIVC responding to requests for over 4500 publications and library items during the past 12 months. Approximatley 500 new articles are added to AIRBASE each year and these are published in a regular quarterly bulletin entitled "Recent Additions". A subject analysis of the contents of AIRBASE is also published regularly. Access to the Database is available either directly through the Centre or, by arrangement, through the supply of regularly updated software copies.

Of increasing importance for the dissemination of information is the AIVC's quarterly newsletter "Air Infiltration Review". Apart from conveying information about the Centre's own activities it contains many technical articles and summaries written by specialists throughout the world. The newsletter also contains information on forthcoming conferences, reviews of recent aquisitions to the Centre's library and an order form for AIVC publications and services. Currently 3500 copies of AIR are distributed quarterly to organisations in 39 countries, making it one of the most widely distributed of International Energy Agency publications.

Another important function of the Centre is to hold regular workshops and conferences. Specialist workshops have covered such topics as wind induced ventilation, airborne moisture problems and measurement techniques. Conferences have a more general subject coverage and are intended to provide an opportunity to strengthen links between the research and application sectors. In recent years the conference has also provided a focus for related IEA tasks.



The information service is complemented by a full technical programme. Initial work concentrated on a numerical model validation exercise, followed by the publication of a comprehensive guide to air infiltration calculation techniques. More recently the Centre has published a companion measurement techniques guide which provides specific guidance on the use of measurement methods for determining air change rates and air flow patterns in buildings. The technical service is also responsible for publishing brief reviews on subjects of topical interest and it undertakes to respond to technical enquiries.

The AIVC is currently submitting proposals for future funding of its activities to include a broadening of its bibliographic and library services, the dissemination of reports generated by other IEA annexes and the development of a basic data guide for air infiltration and ventilation designs. The proposals also include cooperation at a technical level with other IEA task shared projects concerned with room air movement and the control of ventilation in buildings.

Further details concerning the activities of the Centre are available from:

Martin W Liddament
Head
Air Infiltration and Ventilation Centre
Warwick University Science Park
Barclays Venture Centre
Sir William Lyons Road
Coventry CV4 7EZ
Great Britain

* Participants in the AIVC are Belgium, Canada, Denmark, Federal Republic of Germany, Finland, Italy, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom, United States of America.

PEOPLE

Mark Bassett — first visiting specialist to AIVC at Warwick

Mark Bassett from the Building Research Association of New Zealand is the Centre's first visiting specialist.

Mark is contributing to the Centre's programme on the evaluation of multi zone infiltration models as design tools.

He has brought to the Centre a range of interzone air flow data measured in New Zealand houses. In detail, this comprises air flows between subfloor living space and roof space, together with zone temperatures and on site wind speed and direction. The airtightness characterstics of the three zones are also available.

Mark is using multizone models available at the Centre to calculate comparible zone infiltration rates, together with interzone flows, and views this as a preliminary validation exercise, and an examination of the building airtightness data, and exposure to wind data, necessary for a more complete validation.

Further visiting specialist positions at the Centre are available and enquiries should be made to Martin Liddament.

Rhona Vickers — The Centre's new Secretary and Administrative Assistant.

Rhona Vickers joined the Air Infiltration and Ventilation Centre as Secretary and Administrative Assistant at the beginning of September. Rhona has already made a substantial impact on the operation of the Centre and has done much to enure a smooth transition to the AIVC's new location.

PRELIMINARY ANNOUNCEMENT AND CALL FOR PAPERS
AIVC 10TH ANNIVERSARY CONFERENCE

Progress and Trends in Air Infiltration and Ventilation Research
Monday, 25th September – Thursday 28th September, 1989
Venue: Hotel Dipoli, Finland

The AIVC's 10th Annual Conference will be devoted to an overview of progress over the last 10 years (poster session) and on new trends and developments (posters and technical sessions). The conference will comprise three technical sessions, a general group discussion session and two poster sessions.

Presentations and posters are required on current status of ventilation and air infiltration technology and or future trends. "New idea" papers are especially important. Authors contributing to poster sessions will be asked to prepare full length papers for inclusion in the proceedings and an extended summary for circulation during the poster session. Author presentations should concentrate on current status and projections rather than lengthy backgrounds, although a background review within the paper itself will be desirable.

The subject coverage is intended to be broad but will include
- standards
- measurement techniques
- numerical simulation
- air flow simulation
- mechanical ventilation
- building design
- air quality
- demand controlled ventilation

If you wish to contribute to this conference, please forward a detailed 300-500 word abstract to the AIVC by 31st January, 1989. Selection will be based on the content of the abstract and appropriateness to the conference theme. Authors will be notified of acceptance by 31st March, 1989. The choice between poster or author presentation will be made by the selection committee unless a preference for poster presentation is stated.

The conference fee is yet to be finalised but is likely to be in the region of £450 sterling inclusive of full board accommodation from lunch on 25th September to lunch on 28th September inclusive. Registrations will be required by 30th June, 1989, so please reserve the conference date in your diary now.

Abstracts or requests for further information should be sent to:

Martin Liddament,
Air Infiltration and Ventilation Centre,
University of Warwick Science Park,
Barclays Venture Centre,
Sir William Lyons Road,
Coventry. CV4 7EZ
GREAT BRITAIN
Telephone: (0203) 692050
Telex: 312401
Fax; (0203) 410156

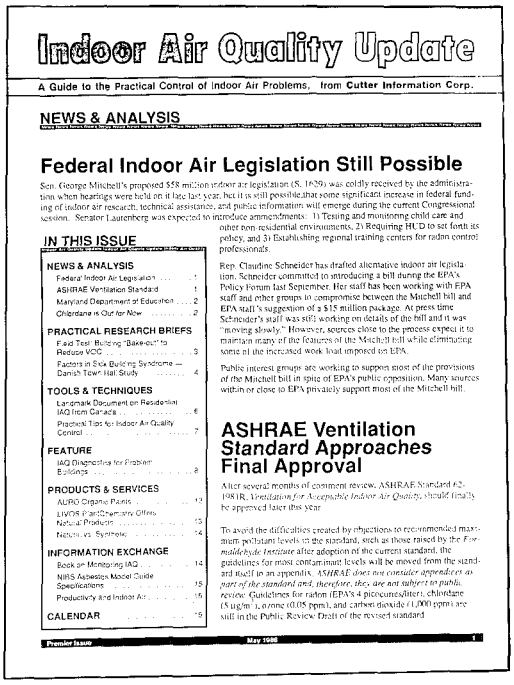
Also you should contact Martin Liddament if you wish to be placed on the conference mailing list.

Book Reviews

Indoor Air Quality Update
A guide to the practical control of indoor air problems
from Cutter Information Corp.

This new monthly newsletter from the Cutter Information Corp. serves as a guide to the practical control of indoor air problems. The first edition, which was distributed in May 1988 includes short articles presented in an accessible manner which may be of use to both the householder and the specialist. Articles are included in categories as follows:

- News and analysis
- Practical research briefs
- Tools and techniques
- Features
- Products and services
- Information exchange


Indoor Air Quality Update

A Guide to the Practical Control of Indoor Air Problems, from Cutter Information Corp.

NEWS & ANALYSIS

Federal Indoor Air Legislation Still Possible

Sen. George Mitchell's proposed $5B million indoor air legislation (S. 1630) was coldly received by the administration when hearings were held on it late last year, but it is still possible that some significant increase in federal funding of indoor air research, technical assistance, and public information will emerge during the current Congressional session. Senator Lautenberg was expected to introduce ammendments: 1) Tesing and monitoring child care and other non-residential environments, 2) Requiring HUD to set forth as policy, and 3) Establishing regional training centers for radon control professionals.

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Rep. Claudine Schneider has drafted alternative indoor air legislation. Schneider committed to introducing a bill during the EPA's Policy Forum last September. Her staff has been working with EPA staff and other groups to compromise between the Mitchell bill and EPA staff's suggestion of a $15 million package. At press time Schneider's staff was still working on details of the bill and it was "moving slowly." However, sources close to the process expect it to maintain many of the features of the Mitchell bill while eliminating some of the increased work load imposed on EPA.

Public interest groups are working to support most of the provisions of the Mitchell bill in spite of EPA's public opposition. Many sources within or close to EPA privately support most of the Mitchell bill.

ASHRAE Ventilation Standard Approaches Final Approval

After several months of comment review, ASHRAE Standard 62-1981R, *Ventilation for Acceptable Indoor Air Quality*, should finally be approved later this year.

To avoid the difficulties created by objections to recommended maximum pollutant levels in the standard, such as those raised by the *Formaldehyde Institute* after adoption of the current standard, the guidelines for most contaminant levels will be moved from the standard itself in an appendix. *ASHRAE does not consider appendices as part of the standard and, therefore, they are not subject to public review.* Guidelines for radon (EPA's 4 picocuries/liter), chlordane (3 ug/m 3), ozone (0.08 ppm), and carbon dioxide (1,000 ppm) are still in the Public Review Draft of the revised standard.

Premier Issue — May 1988 — 1

This edition features articles on a variety of subjects including legislation and standards, building "Bake out" to reduce VOC, factors in sick building syndrome, practical tips for indoor air quality control, AURO organic paints, productivity and indoor air.

Topics for further issues include: chamber tests for VOC emissions from building materials, VOC and sick building syndrome, computer models for predicting indoor air quality during building design, evaluating building materials for indoor air impacts, building design concepts to improve indoor air quality, radon mitigation measures in a Maryland school, LBL reports that energy conservation can improve indoor air quality, GEOMET studies pollutant transport within buildings.

Annual subscription is $207.00
A complimentary copy and further information about any of the other newsletters or reports available from Cutter Information Corp. in the area of advanced building technology are available from:

Cutter Information Corp.
1100 Massachusetts Avenue
Arlington
MA 02174
USA

Tel: (617) 648 8700
Tlx: 650 100 9891 MCI UW
Fax: (617) 648 8707

Energy in the Built Environment The way forward the 1990's

Swedish Council for Building Research G16:1988, Stockholm, Sweden

In recent years, the emphasis of energy conservation and management work in Sweden has tended to concentrate increasingly on the use of electricity, where previously it was concerned more with oil and the dependence of the Swedish energy system on it. The decision to phase out all nuclear power generation by 2010 means that the country will be faced with the need for a substantial restructuring of its energy supply system. Coupled with the effect of other environmental requirements, pressure will increase to achieve efficient energy management and the development of low-pollution technology. In this, the built environment, which accounts for about 40% of the country's total energy use, has a central part to play.

On behalf of the Government, the Swedish Council for Building Research carried out an evaluation in 1983-84 of the results of energy conservation work in buildings between 1974 and 1983 in areas for which the Council was responsible, as well as of the SOL-85 programme which covered the period 1979-1983. The results were presented in the Energy 85 report (D1:1985) and in 25 constituent reports.

Several large and important R & D profects have been concluded since 1984. The Council now feels that it is important to present the results of the new material that has become available, and it is this that has been done in this report. It describes the change in energy use in residential buildings and non-industrial non-residential premises that has occurred since the beginning of the 1970's, together with the potential offered by the built environment for responding to greater demand for more efficient energy use, modernisation and an improvement of the environment in the future. The report pays particular attention to the use of electricity in the built environment. Special emphasis has been given to presentation of the results from a large number of research, development and experimental building projects that have been completed. The report also discusses certain strategic aspects of the built environment that are important in the context of deciding energy policy.

The contents are as follows:

1. The main points of the report.

2. Energy policy and energy-related building research from 1975 to 1987.

3. Energy in the built environment — present-day knowledge and the state of research in 1987.

4. Energy use in the built environment.

5. Potential for energy conservation and more efficient use of energy.

6. Strategic energy considerations in the built environment.

7. Future R & D requirements and R & D structure.

The publication also includes a list of concepts, terms and key words, and an extensive list of references.

Copies of this document are available from:

Swedish Council for Building Research
Sankt Goransgatan 66
S-11233 Stockholm
Sweden

Tel: 08 54 06 40

Forthcoming Conferences

1. Housing for the 90's
29 November — 3 December 1988
Sheraton Tacoma Hotel, Tacoma, Washington

Further details from:

Patricia Anderson
Conference Coordinator
Energy Business Association
420 Maritime Building, 911 Western Avenue
Seattle, WA 98104, USA

Telephone: (206) 622 7171

2. Building Systems: Room Air and Air Contaminant Distribution
5-8 December 1988

Further details from:

Leslie L Christianson
University of Illinois at Urbana-Champaign
Department of Agricultural Engineering
1304 West Pennsylvania Avenue
Urbana, Illinois 61801, USA

Telephone: (217) 333 8220

3. Present & Future of Indoor Air Quality
14 — 16 February, 1989,
Palais des Congres,
Brussels, Belgium.

Further details from:

D. Shanni — E.C.C.O. sprl,
17A Rue Vilain XIIII,
B-1050 Brussels,
Belgium.

4. Excellence in Housing '89,
2-4 March, 1989,
Fort Garry Place,
Winnipeg, Manitoba,
Canada.

Further details from:

Manitoba Energy and Mines,
Tom Akastream,
555-330 Graham Avenue,
Winnipeg, Manitoba
Canada R3C 4E3
or
EEBA Headquarters,
Technology Centre,
University of Southern Maine
Gorham, Maine
USA 04038

5. Symposium on Air Change Rate and Air Tightness in Buildings
17-18 April 1989
Atlanta, Georgia
USA

Further details from:

ASTM Publications Division
1916 Race Street, Philadelphia
PA 19103, USA

6. IAQ 89: The Human Equation: Health and Comfort
17-20 April 1989
San Diego, California, USA

Further details from:

Jim Norman
Manager of Technical Services
ASHRAE, 1791 Tullie Circle
N E Atlanta, GA 30329
USA

7. CLIMA 2000, Second World Congress on Heating, Ventilation,
Refrigeration and Air Conditioning
28 August — 1 September 1989
Sarajevo, Yugoslavia

Further details from:

Branislav Todorovic
CLIMA 2000/KGH, Knez Mihailova 7/II
11000 Belgrade, Yugoslavia
or:
Emil Kulic
CLIMA 2000, Masinski fakultet
Omladinsko setaliste bb
71000 Sarajevo
Yugoslavia

8. XXI International Symposium
Heat and Mass Transfer in Building Material and Structure
4-8 September 1989
Hotel Libertas, Dubrovnik, Yugoslavia

Abstracts should be sent to:

Prof. Jack B Chaddock
School of Engineering, Duke University
Durham, North Carolina 27705
USA

Telephone: (919) 684 2098
Telex: 802829 Duktelcom Durm

One copy should be sent to:

Secretary General Prof. N. AFGAN
International Centre for Heat and Mass Transfer
PO Box 522, 11001 Belgrade, Yugoslavia

Deadlines

Extended Abstracts: January 20, 1989
Announcement of Acceptance: March 1, 1989
Full Papers: April 1, 1989

9. Thermal Performance of the Exterior Envelopes of Buildings IV
4-7 December 1989
Crowne Plaza Hotel
Orlando, Florida

Further details from:

George E Courville
Building Thermal Envelope Systems and Materials
Oak Ridge National Laboratory
PO Box 2008, Oak Ridge, TN 37831-6022
USA

AIVC 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 AIVC publications. *unrestricted availability, free-of-charge.*

Recent Additions to AIRBASE
Quarterly bulletin of abstracts added to AIRBASE, AIVC'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 AIVC library. *Bulletin and copies of papers available free-of-charge to participating countries* only.*

GUIDES AND HANDBOOKS

AIC-AG-1-86-Liddament, M.W.
'Air Infiltration Calculation Techniques — An Applications Guide'
A loose-leaf handbook divided into six chapters covering empirical and theoretical calculation techniques, algorithms, references and glossary of terms. *Available free-of-charge to participating countries* only, via your national Steering Group representative.*

AIC-AG-2-88-Charlesworth, P.S.
'Air Exchange Rate and Airtightness Measurement Techniques — An Application Guide'
A loose-leaf handbook divided into seven chapters covering air change rate, interzonal air flow and building airtightness measurement techniques.

TECHNICAL NOTES

AIC-TN-5-81-Allen, C.
'AIRGLOSS; Air Infiltration Glossary (English edition)'
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, AIC-TN-5.2-84, AIC-TN-5.4-88-Allen, C.
'AIRGLOSS'; Air Infiltration Glossaries (German French, Italian and Dutch) Supplements.

AIC-TN-6-81-Allen,C.
'Reporting format for the measurement of air infiltration in buildings'
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-participating countries.*

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'
Four-section bibliography contains review papers, information on tracer gas techniques, pressurization methods and miscellaneous approaches. In addition the report contains a list of manufacturers of instrumentation currently being used in air infiltration investigations. *Available free-of-charge to participating countries*. Price £15.00 to non-participating countries.*

AIC-TN-11-83-Liddament, M., Allen, C.
'The validation and comparison of methematical models of air infiltration'
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*. Price: £15.00 to non-participating countries.*

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*. Price £20.00 (price includes copy of TN-13.1) to non-participating countries.*

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*. Also available to non-participating countries (see note at TN-13 above).*

AIC-TN-16-85-Allen,C.
'Leakage Distribution in Buildings'
Examines those factors which can influence leakage distribution, including building style, construction quality, materials, ageing, pressure and variations in humidity. *Available free-of-charge to participating countries*. Price: £20.00 to non-participating countries.*

AIC-TN-17-85-Parfitt, Y.
'Ventilation Strategy — A Selected Bibliography'
Review of literature on choice of ventilation strategy for residential, industrial and other building. *Available free-of-charge to participating countries*. Price: £20.00 to non-participating countries.*

AIC-TN-19-86-Charlesworth, P.
'1986 Survey of current research into air infiltration and related air quality problems in buildings'
Fourth worldwide survey by AIVC containing over 200 replies from 19 countries. Produced in two sections: an analysis in tabular form of survey results, followed by reproduction in full of research summaries and list of names and addresses of principal researchers. *Available free-of-charge to participating countries* only.*

AIC-TN-20-87
'Airborne moisture transfer: New Zealand workshop proceedings and bibliographic review'
Proceedings of AIVC's Moisture Workshop, held at BRANZ New Zealand in March 1987, with bibliographic review. *Available free-of-charge to participating countries* only.*

AIC-TN-21-87-Liddament, M.W.
'A review and bibliography of ventilation effectiveness — definitions, measurement, design and calculation'
Reviews definitions of ventilation efficiency and outlines physical concepts, measurement methods and calculation techniques. Includes bibliographic and list of author affiliations. *Available free-of-charge to participating countries* only.*

AIC-TN-22-87-Blacknell,J.
'A subject analysis of the AIVC's bibliographic database — AIRBASE', 5th edition
Comprehensive register of published information on air infiltration and associated subjects. The articles are indexed, and full bibliographic details of the 2,600 documents are given. Also includes the AIRBASE Thesaurus, as well as a list of principal authors. *Available free-of-charge to participating countries* only.*

AIC-TN-23-88-Dubrul,C.
'Inhabitants' behaviour with regard to ventilation.
This report summarises the IEA annex V111 study into the behaviour of occupants with regard to ventilation. It assesses the extent to which the actions of occupants can be modified in order to minimise energy use yet maintain adequate indoor air quality. Chapters cover observational techniques, energy loss due to window opening, reasons for window opening and the resultant energy savings from modified use of windows. *Price: £15.00 to participating countries, £25.00 to non-participating countries.*

AIC-TN-24-88
'AIVC Measurment Techniques Workshop: Proceedings and Bibliography'
Workshop held at Koge, Denmark in March 1988. *Available free-of-charge to participating countries* only.*

CONFERENCE PROCEEDINGS

No.1 'Instrumentation and measuring techniques'. £35.00 sterling.
No.2 'Building design for minimum air infiltration'. Price: £15.00 sterling
No.3 'Energy efficient domestic ventilation systems for achieving acceptable indoor air quality'. Price: £23.50 sterling.
No.4 'Air infiltration reduction in existing buildings'. Price: £16.00 sterling
No.5 'The implementation and effectiveness of air infiltration standards in buildings'. Price: £22.00 sterling.
No.6 'Ventilation strategies and measurement techniques'. Price: £16.00 sterling.
No.7 'Occupant interaction with ventilation systems'. Price: £25.00 sterling
No.8 'Ventilation technology — research and application'. Price: £25.00 sterling.
No.9 'Effective Ventilation' Price: £30.00 sterling.

Please note that the proceedings of AIVC conferences numbers 1-8 are now also available in microfiche form, price £75.00 per set.

**For list of participating countries see back page.*

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Price P+	Free	Free
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Please forward the following publications:

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Price NP	N/A	N/A	12.50	10.00	10.00	7.50	7.50	10.00	10.00	6.00	15.00	15.00
Price P	*	*	12.50	10.00	Free	Free	Free	Free	Free	Free	Free	Free
Quantity												

Technical Note No	13	13.1	14	16	17	19	20	21	22	23	24
Price NP	20.00	20.00	N/A	20.00	20.00	N/A	N/A	N/A	N/A	25.00	N/A
Price P	Free	Free	Free	Free	Free	Free	Free	Free	Free	15.00	Free
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Conference Proceedings	1 (1 Vol)	2 (1 Vol)	3 (2 Vols)	4 (2 Vols)	5 (2 Vols)	6 (2 Vols)	7 (2 Vols)	8 (2 Vols)	1-7 inc (mf)
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Literature Lists (Nos 1–15) .....

Quantity (P only: Free) .....

I enclose a cheque made payable to Oscar Faber Partnership for: £ ..... drawn on a UK bank

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

* Available free of charge to participating countries, via your national Steering Group Representative only (see back of this newsletter)
+P Participating countries
NP Non Participating countries
mf Microfiche
NB All prices are in UK pounds sterling

3rd fold (insert in Flap A)

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2nd fold (Flap A)

1st fold

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