Air Infiltration Review

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8th AIVC Conference

Ventilation Technology – Research and Application

Conference Report – Überlingen, 21–24 September 1987

In his keynote address Dr H. Hlawiczka of the Federal Ministry for Research and Technology in Research and Application outlined the Federal Republic of Germany's approach to ventilation energy efficiency; the main objective is in the identification of technically appropriate solutions for minimising ventilation heat losses in buildings and to transfer such solutions into practical applications as soon as possible. He went on to say that hygiene and comfort are playing an ever more significant role in defining requirements for air exchange and ventilation, hence an integrated view of ventilation in conjunction with a total control of the indoor air environment may become necessary.

Dr Hlawiczka cautioned that the environmental issue as a whole, of which energy is a part, is becoming more and more critical and more urgent. Concerns about irreversible changes to our environment which are also caused by increased energy consumption in all parts of the world are more often being mentioned in debates. Climatic changes caused by the 'greenhouse effect' are no longer speculations but phenomena which have to be seriously and intensively investigated. Should these risks be realistically assessed, then this could lead to changes in living conditions over the whole world which cannot be estimated.

International cooperation through the IEA in relation to the exchange of information as well as the development of joint strategies to introduce new technologies was regarded as of great importance. In concluding, Dr Hlawiczka stressed the importance that this type of conference has in the exchange of information and experiences in contributing to achieve better indoor air quality, to reduce ventilation heat loss and to identify economic and user-accepted ventilating systems.

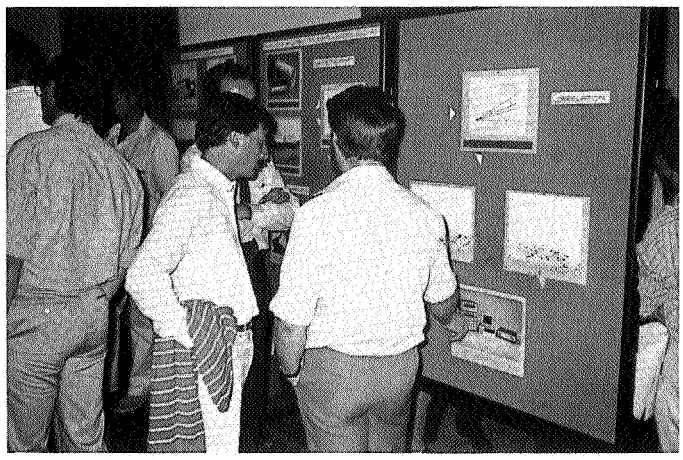
Following the keynote presentation, Peter Charlesworth of the AIVC introduced a session on measurement techniques by outlining the contents of the Centre's forthcoming Measurement Techniques Guide. This was followed by presentations on tracer gas techniques covering infiltration and air movement in large buildings, the use of multiple tracers for interzonal air movement studies, field comparisons of the constant concentration and passive perfluorocarbon methods and the estimation of air change rate based on the concentration of metabolic carbon dioxide.

Air leakage and airtightness measurements were also discussed in relation to the measurement of draughts, the use of thermography for air leakage measurements, the effect of air vapour barrier thickness on airtightness and the estimation of air infiltration in multi-storey buildings using wind tunnel tests.

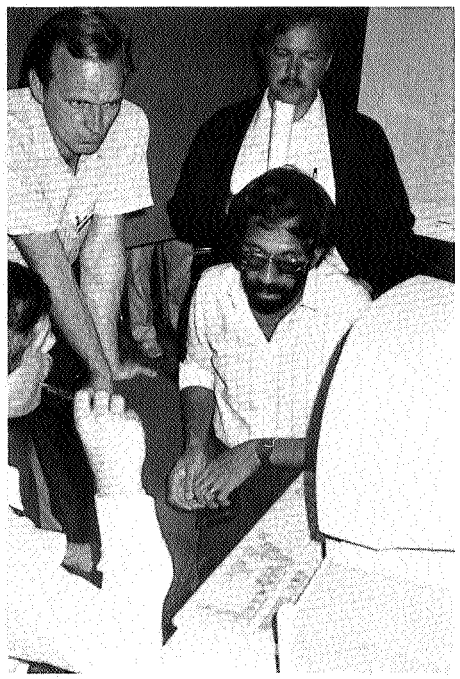
Inside this issue:

Numerical applications covered data needs for air infiltration computer code evaluation, the application of a simplified model for predicting airflows in multizone structures and the use of statistics for predicting the distribution of air infiltration.

In terms of ventilation design much interest was shown in the potential of dynamic insulation as a means to preheat incoming air. Presentations included a paper on the thermal coupling of leakage flows and heating load of buildings, and a paper on the design, construction and performance of a dynamic wall house. Other contributions on design covered an overview of the Canadian R-2000 Home Program and ventilation requirements, demand controlled ventilation and the role of occupants in relation to window opening. The influence of ventilation design was also presented on the moisture load on dwellings as a function of room layout and a presentation on the prevention of moisture by ventilation of the foundation.



Discussing the ventilation research performed by British Gas



Demonstration of BREEZE, a multi-zone infiltration model, by Earle Perera (BRE – United Kingdom)

Steve Irving of Oscar Faber Consulting Engineers, UK, the Operating Agent of the Centre, presented the final paper which reviewed the activities of the IEA within the Building Energy Conservation Implementing Agreement of which the AIVC is part.

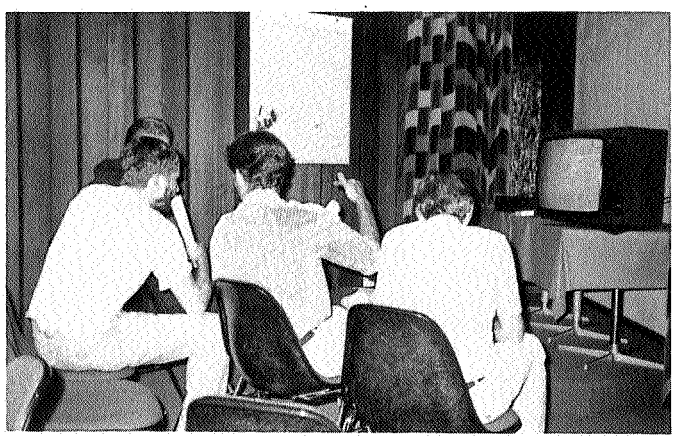
This was followed by the summing up in which Mike Holmes of Arup Research and Development, London presented the view of the consulting engineer. He grouped the papers under four headings, these being measurement, prediction, design and positive aspects of ventilation. With regard to measurements he thought that techniques were still in the development stage with no compact instrument available to the consulting engineer for the accurate measurement of infiltration rates. The development of simple methods based on PFT's and bag sampling was regarded as important, since this provided the client with a good idea of the performance of an existing building. Under these circumstances, precise volumes were not always important with errors of ± 0.25 or even 0.5 ach being satisfactory. It was hoped that many of these problems would be solved with the publication of the AIVC Measurement Techniques Guide next year.

With regard to calculation techniques, Mike Holmes emphasised the great interest in the subject, especially in relation to validation and complexity of model. He said that unless methods for validation are available, arguments over techniques are not very relevant. Essentially, two forms of validation need to be considered. These are:

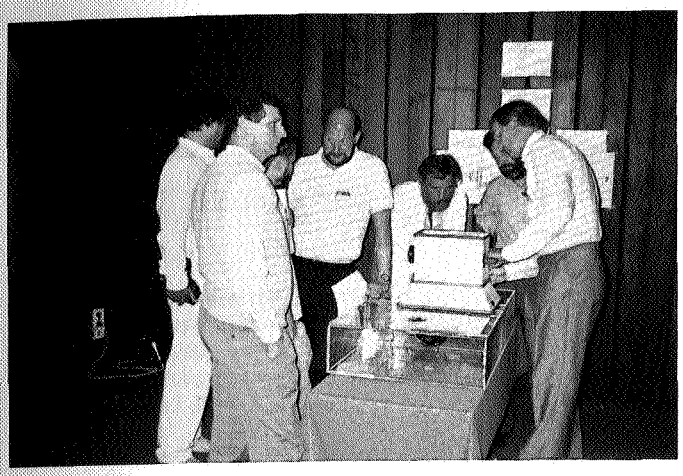
- will the method reproduce a standard of design calculation
- will the method reproduce measured data.

It was argued that the first, while applicable to many computerized design methods, is probably not valid at the moment with respect to infiltration and ventilation calculations. On the other hand, the reproduction of experimental results implies that suitable data (together with error assessments) are available. Mike went on to say that the task of providing such datasets should not be underestimated as they must contain all relevant parameters and be demonstrated as suitable for validation checks. The suggestion was that a central record of validated datasets be created and that this was an obvious task for the AIVC.

In relation to the choice between simple and complex calculation techniques, this was only thought to be mportant if the data input to simple models was also simple. It was argued that the availability and application of suitable hardware for the more complex techniques is no longer a discussion point. In general it can be said that even with the most sophisticated computer programs, data preparation and checking time exceed the run time. This is particularly true for what may be the ultimate infiltration model – computational fluid dynamic codes. Cited as an encouragin trend in the development of prediction techniques, was the introduction of statistical methods in an attempt to reproduce the variations found in practice. More work in this area was recommended although again, validation was regarded as all important. An interesting aspect was to see how predictions would check out against some of the large sample surveys now being carried out.



Discussion following a video about thermographic imaging techniques



Demonstration of compensating flow measurement device by Hans Phaff (TNO – Holland).

From the design aspect, it was argued that the best way to get acceptable air quality throughout a building, is to ensure that appropriate quantities of fresh air are delivered to each occupied zone rather than to rely on the random effects of weather and adventitious openings. It was stated that the design of suitable systems is trivial for engineers familiar with the design of commercial buildings, however it appears that those who only have experience of dwellings have some difficulty in accepting such concepts. There is a need therefore, to educate the industry and to demonstrate the need for and advantages of good ventilation design.

With regard to the positive aspects of ventilation, passive heat recovery of infiltrating air combined with dynamic insulation was cited as an interesting development. Again the difficulty was seen as the need to make very precise measurements in order to validate the theory. Finally the need to be aware of differences between countries was emphasised. Not only did this apply to climatic differences but also to attitude.

As well as the formal presentations a very successful and well attended poster session enabled authors to provide more detailed descriptions of current research developments.

In addition to posters, video presentations, computer simulations and an equipment demonstration were displayed. There was also a computer link up to the Building Research Association in New Zealand for a demonstraiton of 'DAMP' on expert system for diagnosing damp in homes.

Technical visit to Graf Zeppelin House Conference centre

A technical visit was made to the Graff Zeppelin House in Friedrichshafen where participants had the opportunity to inspect the ventilation, heating and air conditioning plant of this huge multi-purpose conference and entertainment centre.

9th AIVC Conference

'Effective Ventilation'

Call for Papers

Novotel, Ghent, Belgium
12 – 15 September 1988

Next year's conference is intended to provide an opportunity for researchers and practitioners to exchange ideas on both new developments and the operational performance of recently implemented ventilation techniques.

Contributions covering the following topics are particularly welcome.

- New developments
- Airflow in buildings
- Demand control
- Air quality and energy implications
- Occupant perception
- Comfort
- Optimum airtightness
- Case studies
- Future trends
- Standards
- Definitions

Abstracts, not exceeding 200 words, of proposed papers on the above topics are welcome and should be received by the AIVC no later than 31 January 1988. The abstracts will be subjected to review in March 1988 and print-ready copies of accepted papers will be required in July 1988. Submissions from the non-AIVC participating countries are welcome and, if the abstracts are accepted, the authors will be invited to participate in the conference.

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

Programme and registration will be published in the May 1988 edition of AIR. Booking forms will be obtainable from your Steering Group Representative. Meanwhile, please reserve the conference dates 12 – 15 September 1988 in your diary.

Ventilation Rate Measurement

Occupant-Generated CO_2 as a tracer gas in a field of study of ventilation rate
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Introduction

Some guidelines[1] on indoor-air quality specify a maximum allowable exposure to CO_2. In a room ventilated by a mechanical extract system a control program on the CO_2 concentration may, by an appropriate sampling strategy, supply information about the exhausted flowrate. This paper briefly outlines a simple analytical model for estimating the exhausted flowrate by measuring the CO_2 concentration and keeping a record of the occupancy of the room. The CO_2-data from a field study is applied to the model and the estimated flowrate is compared to the flowrate obtained by a well established tracer gas technique.

The Analytical Model

In a room a tracer gas is released at a rate m(t) and the volume of the room is denoted V. At time t let the flowrate of exhausted air be denoted Q(t). Assuming the homogenously mixed gas concentration of the room is C(t), and the gas concentration of the supply air is $C_s(t)$; the continuity equation gives the following well known expression for the tracer gas content of the room:

$$V \frac{d\,C(t)}{dt} = M(t) - [C(t) - C_s(t)]\,Q(t) \qquad [1]$$

If it is assumed that Q is time-independent Q can be obtained after integrating Equation [1] from t0 to t1:

$$Q = \frac{\int_{t0}^{t1} M(t)\,dt - \int_{C(t0)}^{C(t1)} V\,dc}{\int_{t0}^{t1} [C(t) - C_s(t)]\,dt} \qquad [2]$$

It is assumed that C(t) is continuously recorded and by selecting t0 and t1 so that C(t0) = C(t1) the rate of exhausted air may be conveniently calculated[2] by:

$$Q = \frac{\int_{t0}^{t1} M(t)\,dt}{\int_{t0}^{t1} [C(t) - C_s(t)]\,dt} \qquad [3]$$

The tracer gas considered may be occupant-generated CO_2. For the period t0 – t1 let the dose of CO_2 above the fresh air level be denoted D(t0 – t1). Let the number of occupants at time t be denoted N(t) and the average CO_2 generation rate per occupant be denoted G(t). If it is assumed that G is time independent Q is obtained from Equation [3]:

$$Q = \frac{G \int_{t0}^{t1} N(t)\,dt}{D\,[t0 - t1]} \qquad [4]$$

where

$$D\,[t0 - t1] = \int_{t0}^{t1} [C(t) - C_s(t)]\,dt \qquad [5]$$

The rate of exhausted air, Q, can be estimated by integrating the occupancy and concentration functions over the chosen time period using the appropriate CO_2 generation rate G. Alternatively Q may be estimated by integrating Equation [1] from t0 to t assuming m(t) = 0 and $C_s(t) = 0$, i.e:

$$C(t) = C(t0)\,e^{-\left(\frac{t\,Q}{V}\right)} \qquad [6]$$

From the tracer decay relationship (Equation (6)) the air change rate is readily estimated by observations of C(t) vs t. In practice it may be appropriate to justify the assumed spatial homogenous mixing of the tracer in a decay test by estimating the air exchange efficiency $\langle \epsilon_a \rangle$. If the mean-age of air in the room is denoted $\langle \tau \rangle$ then[3]:

$$\langle \tau \rangle = \frac{\int_{t0}^{\infty} t\,C_e(t)\,dt}{\int_{t0}^{\infty} C_e(t)\,dt} \qquad [7]$$

and

$$\langle \epsilon_a \rangle = \frac{[V/Q]}{2\langle \tau \rangle} = \frac{\left[\int_{t0}^{\infty} C_e(t)\,dt\right]^2}{2\,C_e(t0)\int_{t0}^{\infty} t\,C_e(t)\,dt} \qquad [8]$$

In Equations [7] and [8] the subscript e indicates the concentration in the exhaust air, and it is noted that $\langle \epsilon_a \rangle$ = 0.50 in case of complete mixing.

Measurements

All the reported tests were performed as part of a field study of a kindergarten with previously reported complaints about indoor-air quality. The room selected for the tests was ventilated by a mechanical extract system with an outlet in the ceiling (see Fig 1, Position 1). The net volume of the room, which contained only a few tables, was 290 m^3. The intake of fresh air was provided by grills under the windows. During the initial test period the $C0_2$-concentration vs time throughout the room (See Fig 1, Positions 1-6) and incoming fresh air were sequentially recorded (45 second intervals) by a portable computer controlled unit (Fig. 2). In the same test the occupancy was recorded every fifteenth minute, and the occupant motion through the door was unrestricted. Following the initial test a tracer gas (SF_6) was injected and homogeneously mixed in the now unoccupied room. The tracer decay was measured by the portable unit using the previously outlined experimental setup modified to only one sampling point (No. 1), and the door was closed throughout the test period.

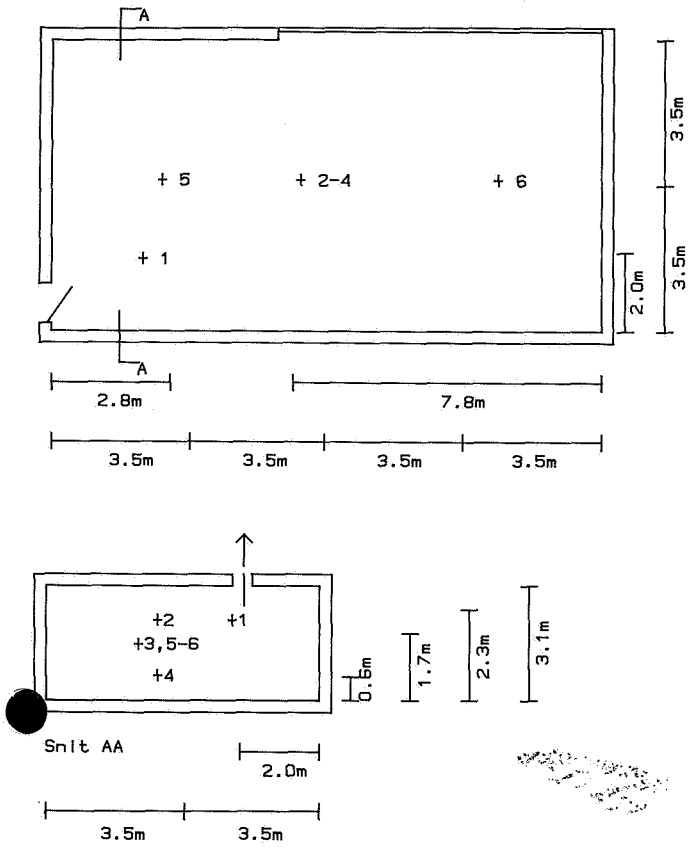

Figure 1: The test room in the kindergarten

Results

The initial test period lasted 315 minutes, and an example of the measured CO_2 concentration vs time at Position 1 is shown in Fig 3. The time-weighted average concentration of the test period at the six positions considered ranged between 1210-1390 ppm indicating a basically spatial homogeneous concentration. The average CO_2-concentration in fresh air was 360 ppm. Selecting the CO_2 data from Position No. 1 for estimating the exhausted air flow a detailed analysis of the data indicated that C(t0) = C(t1) for t0 = 0 and t1 = 231 minutes. The estimated dose above the fresh air level of that period is listed in Table 1. Also shown in Table 1 are the summarized data of the occupancy and the CO_2-generation rate. Assuming a respiratory quotient (RQ) of 0.83 and a metabolic rate of 1.8 met the CO_2-generation rate per adult was estimated to be 0.027 m^3/h and per child the rate was estimated to be 0.010 m^3/h. By data from Table 1 and using Equation [4] the estimated exhausted airflow was 230 m^3/h.

Table 1: CO_2 Data from Kindergarten Field Study

Period min	No. of adults	Amount of generated CO_2 m^3	No. of children	Amount of generated CO_2 m^3	Dose above the fresh air level min m^3/m^3
0–75	5	0.168	18	0.225	
75–105	7	0.094	18	0.090	
105–150	1	0.020	11	0.083	
150–165	3	0.020	11	0.028	
165–180	4	0.027	0	0	
180–195	0	0	0	0	
195–210	3	0.020	0	0	
210–231	2	0.019	0	0	
Total		0.368		0.426	0.206

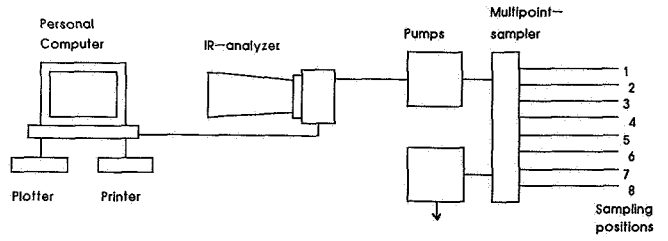

Figure 2: Portable computer controlled tracer sampling unit

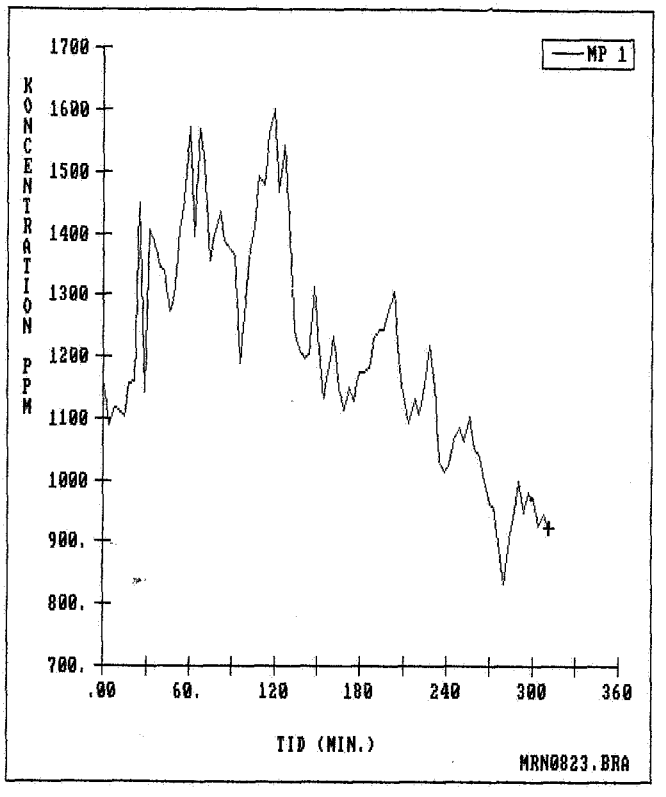

Figure 3: CO_2 concentration vs time for Position 1 in Figure 1

The measured SF_6-tracer decay of the non-occupied room was analyzed by logarithmic regression and the estimated air change rate was $1.1h^{-1}$ (r^2 = 0.99) i.e. the estimated exhausted airflow was 320 m^3/h. By Equation [7] the estimated mean-age of air in the room was 57 minutes and by Equation [8] the estimated air exchange efficiency was 53%.

Discussion

Occupant generated CO^2 has previously[4] been used as a tracer for characterizing the ventilation process of a room. It is well recognised, however, that the generation rate per occupant depends on the respiratory quotient and the activity level of the individual[1]. The respiratory quotient is the volumetric ratio of carbon dioxide to the oxygen consumed. It varies from 0.71 for a diet of 100% fat to 0.80 for a diet of 100% protein and 1.0 for a diet of 100% carbohydrates. In the present study a value of RQ = 0.83 was applied assuming the diet being a normal mix of fat, protein and carbohydrates. A graph on the relationship between the CO_2 generation rate and the activity level is available,[1] and in the present study a metabolic rate of 1.8 met on average (light physical activity) was applied. The CO_2 generation rate per child was estimated from a previously reported[5] kindergarten study.

The estimated exhausted airflow came to 68% of the decay test estimate. Neglecting the air exchange through the door and considering the basically spatial homogeneous gas concentrations in the two tests reported the observed discrepancy between the estimated exhausted airflow rates might have been caused by an inadequate technique in estimating the occupant CO_2 generation rate. Previously it has been reported[4] that for a specific activity it will usually be possible to predict an individual's CO_2 production within 10%, and so in the present study a more detailed observation of the occupancy and the activity might have reduced the reported error of the outlined simple analytical model.

Conclusion

A control program on the CO_2 concentration in a well mixed room may by an appropriate sampling strategy also supply information on the exhausted flowrate. The outlined analytical model is simple but it is emphasized, however, that an accurate estimate of the CO_2 generation rate is needed.

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Ventilation Research in Hungary

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Introduction

Ventilation research in Hungary dates back to the early 1960's, when the mass production of multi-storey tower blocks began. At that time the main aim of most research activity was to develop suitable ventilation strategies for this type of building. Two solutions were developed and have been in use since that time.

For buildings with up to four storeys, natural ventilation, with built in collecting ducts for the exhaust air, is utilised. For buildings with more than four storeys mechanical extract ventilation with collecting ducts equipped with roof mounted fans is used. The fresh air supply is provided by infiltration through cracks around the windows. The other large section of Hungarian building stock, family and detached houses, do not possess active ventilation systems. However, the multi-storey buildings have always posed more problems with regard to ventilation than the detached houses.

After the oil crisis in the seventies the main aims of ventilation research changed. Many energy saving measures had been taken by the authorities, among them the reduction of infiltration heat losses. The Ministry of Building and Urban Development ordered the production and installation of better quality airtight windows, and the draughtproofing of existing window assemblies. Since about 1980 the wide use of these window structures has led to a variety of difficulties with indoor air quality, and recent ventilation research in Hungary has been aimed at providing solutions to these problems.

Ventilation problems

When airtight windows are installed the fresh air change rate, whether provided by natural or mechanical means, is reduced. The practical consquences of this are:

- High concentrations of indoor contamination and odour, and in the worst cases insufficient fresh air for human needs.

- High indoor relative humidity and condensation.

- Mould growth (this occurs only in certain cases and depends upon the prevailing conditions).

The latter phenomenon, which is more significant than the first two, caused many problems and in some cases led to lawsuits between builders and owner-inhabitants. Some of these problems can be attributed to inadequate ventilation practice. Factors specific to this area are:

- There are no suitable 'low cost' ventilation systems or solutions to the changed circumstances.

- Coherent and uniform codes of practice and regulations are required by those involved in design and installation activity.

- Special regard must be made to the reconstruction and restoration of old buildings.

- Suitable technical solutions must be provided for the existing problems mentioned above.

- There is a lack of measurement methods for quantifying the leakage and air change rate of existing buldings.

Research Projects Launched

In order to develop solutions for existing ventilation problems several research projects have been launched.

Development of Regulations

This work has started with the revision of existing codes and the preparation of modifications. New calculation methods have been devised for use at the design stage, and these separate out the heat losses due to conduction and infiltration (1).

These new methods have created the demand for more detailed input information such as meteorological data and wind pressure coefficients. A separate project has been launched to establish a wind pressure data bank based on wind tunnel experiments examining dwellings and industrial buildings. The greater part of this work has already been performed and the data processing for IBM – compatible computers is now in progress (2). Figure 1 shows an instrumented model placed in the wind tunnel.

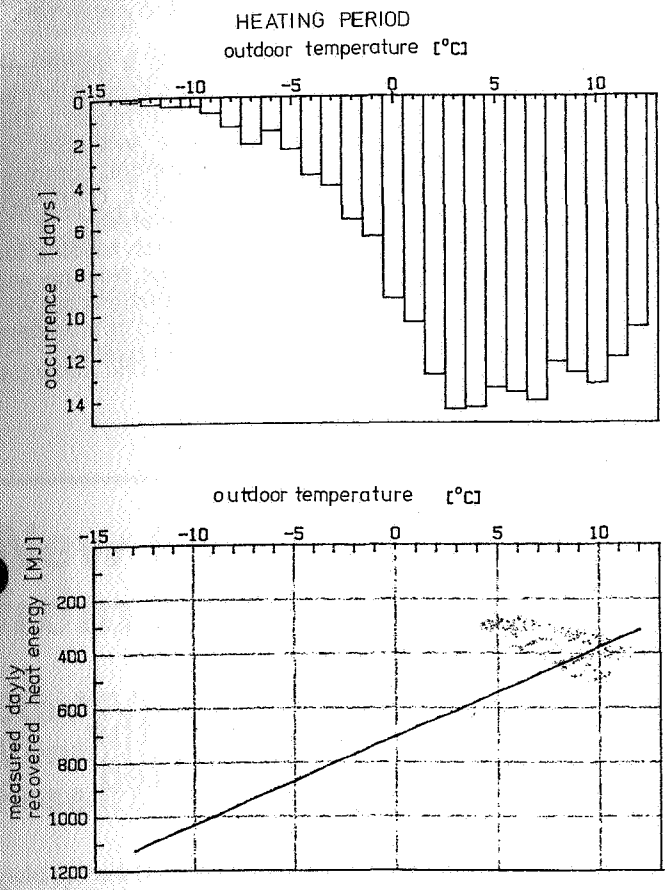

Figure 1: A model of a Row of Blockbuildings in the Pressure Test Wind Tunnel

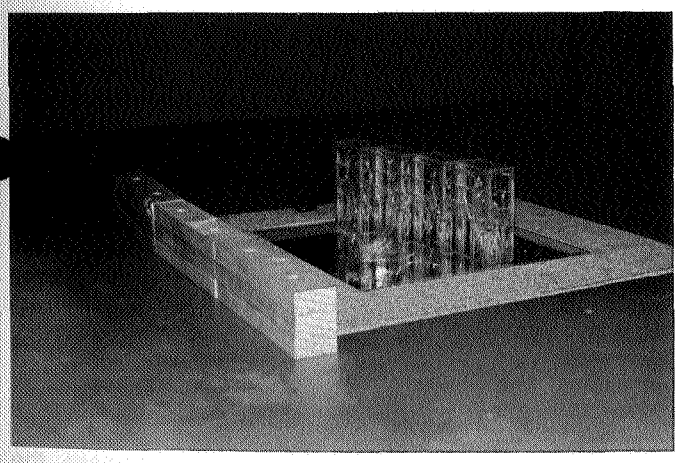

Figure 2: Evaluation of Energy Saving Potential of Balanced Ventilation System with Heat Recovery

Development of Ventilation Systems

To eliminate the consequences of insufficient ventilation in dwellings both short and long term solutions were proposed. In the short term, supplementary fresh air inlet devices were designed and installed under existing windows (3). These allowed the ingress and distribution of fresh air while providing protection against outside noise, dust, insects and unwanted wind effects. Laboratory and site measurements have been performed and on the basis of successful results the production of these devices has begun.

The long term solution rests with a newly designed balanced ventilation system. This has been evaluated by a one year monitoring project in a newly occupied 11 storey building(4). The system is equipped with a heat recovery battery and has proved to be energy efficient, also no complaints from the user-inhabitants were encountered.

Figure 2 shows the occurrence of outdoor temperature during the heating season in Hungary and the measured daily heat energy recovered by the ventilation system.

The predicted amount of regainable energy during a heating season is given by:

Summation of recovered heat energy weighted with relative occurance of outdoor temperature:	106.8 (GJ)
Summation of surplus energy consumed:	17.8 (GJ)
Regainable energy during a heating season:	89.0 (GJ)

Measurement Techniques

A recently started project intends to establish a pressurization rig and equipment for measuring tracer gas concentrations.

The main parts of the system are ready. For leakage determination an axial fan with thiristor control and equipment for pressure and velocity measurement are used. For the tracer gas technique the basic apparatus to be used is an URAS 7N Infrared gas analyser prepared for N20 tracer. It is intended to develop a constant concentration method which will be applied to multicell measurements of the fresh air change rate in each cell.

Conclusions

Ventilation problems in Hungary have promoted extensive research and development in several fields. The focus of the research is directed towards ventilation of dwellings where low air change rates have led to indoor air quality problems. Consequently technical solutions must be developed and implemented. These have to meet the requirements of energy saving, user demands and investment and operational cost.

While this report deals with domestic buildings, several ventilation research projects examining industrial or farm buildings have been investigated. During this research and development activity it is felt that cooperation with other reseachers working in these areas would be of mutual benefit.

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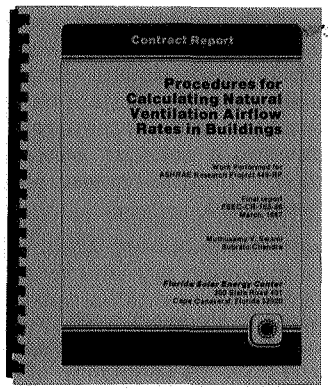
Book Reviews

Procedures for Calculating Natural Ventilation Airflow Rates in Buildings

By Muthusamy V. Swami and Subrato Chandra
Final Report FSEC-CR-163-86, March 1987
Florida Solar Energy Center, 300 State Road 401, Cape Canaveral, Florida 32920

This is the final report of ASHRAE research project 448-RP 'Building Pressure Distribution for Natural Ventilation' initiated in October 1985. The objective of the research was to review the worldwide data on building pressure coefficient and to assimilate the data for use in hourly calculation of natural ventilation airflow rates in buildings. This report is organised in two parts. Part 1 is written for the user who wants to use the information. Part 2 provides the background and research data analysis which was conducted to come up with the Part 1 information.



The worldwide database on building pressure (Cp) distribution was reviewed and usable detailed data on low rise and high rise buildings were extracted. Data was assimilated from eight different investigators for low rise buildings and one source for high rise buildings. For low rise buildings, it was found that surface average pressure coefficients were adequate and several thousand local data were assimilated as 544 surface average Cp. A non linear regression with wind incidence angle and building side ratio as variables was found to predict this data with a correlation coefficient of 0.80.

For high rise buildings, local pressure coefficients (rather than surface average) were used. The 5000+ data points were fitted with another non linear regression involving the earlier variables plus the location coordinates. Over 80% of the effort in this project went into the development of these regression equations and is detailed in part 2 of this report. These building pressure coefficient correlations developed in this work can be useful for infiltration and indoor air quality studies as well as for natural ventilation airflow calculations.

Part 1 of the report presents a structured procedure for calculating wind driven natural ventilation air flow rates. This procedure is based on the Vickery algorthm for calculating airflows with enhancements to the procedure for handling the following special cases:

- Projecting windows and insect screens
- Minimum ventilation rates in zero wind conditions
- Effect of surrounding buildings
- Ventilation in windows only on one wall

The recommended procedure was verified by comparing it to measured natural ventilation air flow rates in a full scale three bedroom two bathroom house. It was found that the procedure predicted measured airflow rates to within 10%.

The authors believe that the procedure is a significant enhancement to the state of art. However the procedure has many limitations which are spelled out in detail in part 1. The most severe limitation is that the entire available Cp database is on rectangular buildings. Therefore, common houses with garages and porches which have L, U or more complex shapes cannot be readily analysed. It is recommended that ASHRAE consider research funding for obtaining Cp data on non rectangular buildings. Not only will this be important for natural ventilation calculations but will be vital for accurate infiltration calculations and its attendant impact on energy conservation and indoor air quality.

Copies are available from:
Subrato Chandra
Florida Solar Energy Center
300 State Road 401
Cape Canaveral, EL 32920
USA

The Proceedings of the International Seminar on the Promotion of Demonstrated Energy Technologies

27 – 28 October 1986,
Queen Elizabeth II Conference Centre London UK

The Department of Energy, United Kingdom
The Commission of the European Communities
The International Energy Agency.

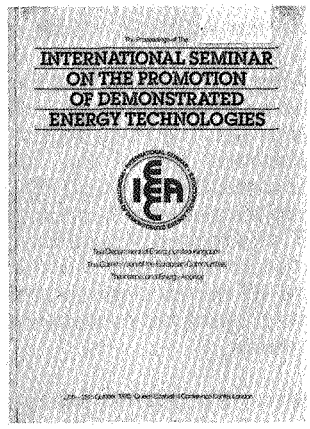
The International Seminar on the promotion of Demonstrated Energy Technologies was organised by the UK Department of Energy with the support of the Commission of the European Communities and the International Energy Agency and was jointly funded by those three bodies. It took place on the 27 and 28 of October 1986 at Queen Elizabeth II Conference Centre in London and was attended by a hundred invited delegates from twenty three countries. Most of those present were directly involved in the running of energy demonstration schemes within their respective countries and organisations. Also present, however, were delegates from industry, from local authorities and from utility companies together with independent experts and consultants.

The main aim of the Seminar was to increase the effectiveness of national and international efforts in bringing about the actual widespread adoption of improved energy technologies through the demonstration process by providing an opportunity for those involved in such activities around the world to compare their experiences and describe the approaches which they had found to be the most effective.

The oil crisis of 1973 and subsequent events brought a general awareness of the need for the OECD countries to improve the efficiency with which energy is used and to encourage the adoption of alternative sources of supply. It soon became evident that a major barrier to the commercial use of the new and better technologies was lack of confidence in the minds of potential users with respect to the technical and economic acceptability of these technologies.

Many countries responded by setting up 'Demonstration' or analogous schemes for new energy technology in order to establish the true facts and to build confidence. On an international level, the Commission of the European Communities has, since 1978, funded a demonstration programme which is now the largest in the world, while the International Energy Agency has encouraged and established a framework for collaborative projects. Schemes vary and some are described in an Appendix to this volume. The essential features are, however, common to all and include full commercial scale and rigorous monitoring of both technical and economic results. It has recently been estimated that there are some 3500 demonstration-type projects completed or in progress throughout the OECD countries.

The Proceedings contain papers from the eight sessions, together with additional papers, a section on descriptions of national and international demonstration or analogous activities, and a list of delegates.



Copies are available from:
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New Publications from the AIVC . . .

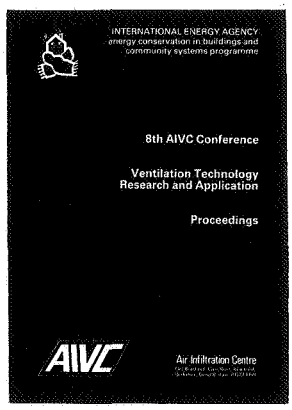
8th AIVC Conference: Ventilation Technology, Research and Application

Held at Park Hotel St. Leonhard, Überlingen, Federal Republic of Germany 21 – 24 September 1987

Proceedings

The proceedings of the 8th AIVC Conference are now available, with a supplement to follow shortly. The publication includes 14 papers given at the conference, as well as details of 11 of the posters presented at the poster session.

Copies are available from the AIVC, price £25.00.



Recent Additions to AIRBASE

From August 1987, the AIVC's current awareness bulletin, Recent Additions to AIRBASE includes a new Subject Key, intended as a basic subject guide to the contents. Reference numbers to records are arranged under fourteen separate subject headings, forming a quick reference guide to each edition.

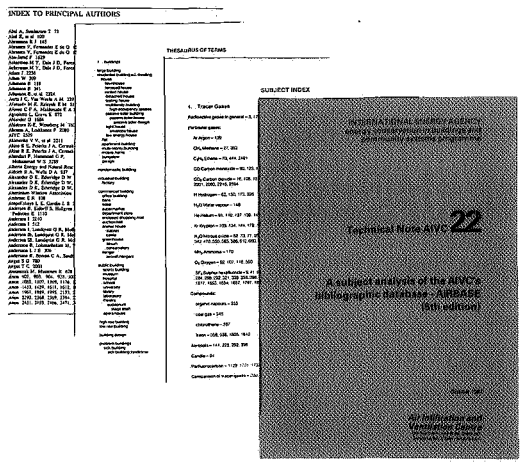
AIVC-TN-22-87: A Subject Analysis of the AIVC's Bibliographic Database – AIRBASE (5th edition)

The new Subject Analysis of AIRBASE will soon be available. The Analysis is in effect a 'hard copy' of the AIVC's bibliographic database, AIRBASE, and will supersede AIC-TN-18-86. The publication is divided into four sections:

1. Subject Index
2. List of References in AIRBASE
3. AIRBASE Thesaurus
4. Index to Principal Authors

Section 1 contains the analysis itself, in which articles are listed by reference number under one or more of 14 major subject headings. Each heading is further subdivided to give a total of 228 areas.

Section 2 contains a listing of author, title and bibliographic details in reference number order, thus providing an index to the papers referenced in Section 1.



Section 3 contains the AIRBASE thesaurus of keywords, accompanied by a Full Index and Short Index. It is intended as an aid to searching the computerised database itself, and is included here as a useful additional guide to the subject coverage of the database. The FULL INDEX to the thesaurus contains an alphabetical list of the keywords used in AIRBASE, together with USE and USED FOR (UF) references, guiding searchers to the preferred term, and a list of broader (BT), narrower (NT) and related (RT) terms for each keyword. BT and NT terms locate the keyword within its hierarchy in the thesaurus, and RT terms provide cross references to other related or useful terms not necessarily within the same section of the thesaurus.

A list of principal authors is given in Section 4.

The analysis will be a useful guide to all those involved in the field of air infiltration and related subjects. It is available free of charge to members in participating countries.

Dutch Translation of the AIVC's Publication 'Air Infiltration Control in Housing'

Beheersing van de luchtinfiltratie in woningen. Handboek voor de nederlandse bouwereld.

The Dutch version of the Air Infiltration Handbook has now been prepared in draft form. It is expected to be available soon from:

TNO Division of Technology for Society
PO Box 217
2600 Delft
Netherlands
Tel: 015 – 569330
Telex: 38071

Forthcoming Conferences

1. Housing for the 90's
   Meeting the Challenges of a Changing Market
   2–5 November 1987
   Sheraton Tacoma Hotel, Tacoma, Washington, USA

   Further details from:

   Energy Business Association
   420 Maritime Building
   911 Western Avenue
   Seattle
   Washington 98104, USA
   Tel: (206) 622-7171

2. Humidification and Humidity
   A Symposium Sponsored by TC8.7 Humidifying Equipment at the ASHRAE Winter Meeting
   31 January – 3 February 1988
   Dallas, Texas

   Titles and Abstracts to:

   Gary L. Berlin
   Nortech Industries, Inc
   26–28 Market Square
   2nd Floor, Suite A
   Manheim PA 17545

3. Energy '88
   The 2nd International Congress on Energy
   5–10 June 1988
   Tiberias (on the shores of the Sea of Galilee)
   Israel

   Further details from:

   Congress Secretariat
   International Congress on Energy
   International Ltd
   PO Box 29313
   65121 Tel Aviv
   Israel

4. PLEA '88
   Passive and Low Energy Architecture
   'Energy and Buildings for Temperate Climates'
   A Mediterranean Regional Approach
   27–31 July 1988
   Porto, Portugal

   Further details from:

   PLEA '88
   Av. Antunes Guimaraes, 102-1 Sala 7
   4100 Porto
   Portugal
   Tel: (02) 67 85 88
   Telex: 27323 FEUP P

5. Healthy Buildings '88
   CIB Conference in Stockholm, Sweden
   5–8 September 1988

   Further details from:

   CIB/Healthy Buildings '88
   c/o Stockholm Convention Bureau
   PO Box 6911
   S-10239 Stockholm
   Sweden

6. Ventilation '88
   2nd International Symposium on Ventilation for Contaminant Control
   20–23 September 1988
   Imperial College of Science and Technology
   London, Great Britain

   Further details from:

   Ventilation '88
   British Occupational Hygiene Society
   1 St. Andrew's Place
   Regent's Park
   London NW1 4LB
   England

7. 9th AIVC Conference
   'Effective Ventilation'
   12–15 September 1988
   Novotel Hotel, Gent, Belgium

   Further details from:

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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.*

HANDBOOK – Elmroth, A., Levin, P.
'Air infiltration control in housing. A guide to international practice'
An international guide to airtightness design solutions of great practical value to all those concerned with the design of pollution – free dwellings with low energy demands. *Unrestricted availability. Price £12.50 hard copy. Also available in microfiche £10.00.*

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 – Allen, C.

AIC-TN-5.2-84 – Allen, C.

AIC-TN-5.3-84
'AIRGLOSS': Air Infiltration Glossaries (German, French and Italian) 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.* (Being reprinted.)

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 mathematical 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-12-83 – Liddament, M.
Superseded by TN19 (see below).

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

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* only.*

AIC-TN-17-85 – Parfitt, Y.
'Ventilation Strategy – A Selected Bibliography'
Review of literature on choice of ventilation strategy for residential, industrial and other buildings. *Available free-of-charge to participating countries* only.*

AIC-TN-18-86 – Parfitt, Y.
Superseded by TN22 (see below).

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 particpating countries* only.*

AIC-TN-20-87
'Airborne moisture transfer: New Zealand workshop proceedings and bibliographic review'
This document presents the proceedings of the AIVC's Moisture Workshop, held at the Building Research Association of New Zealand (BRANZ) on 23 March 1987. It includes the opening address by the Hon. Margaret Shields, Associate Minister of Housing, New Zealand, and the full text of the ten papers presented, together with a record of the discussion. The second section presents a review of literature on the subject and a bibliography taken from papers in the AIVC's bibliographic database, *AIRBASE. 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'
The objective of this report is to review the various definitions associated with ventilation efficiency studies and to outline the physical concepts, measurement methods and calculation techniques. A detailed bibliography gives references to articles useful for more detailed research. An appendix presents the country of affiliation of authors references in the bibliography, in order to assist in comparing the needs of different countries or climatic regions. *Available free-of-charge to participating countries* only.*

AIC-TN-22-87
'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.*

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

No. 1 Pressurization – Infiltration Correlation: 1. Models (17 references).
No. 2 Pressurization – Infiltration Correlation: 2. Measurements (26 references).
No. 3 Weatherstripping windows and doors (30 references) - updated.
No. 4 Caulks and sealants (30 references) - updated.
No. 5 Domestic air-to-air heat exchangers (25 references).
No. 6 Air infiltration in industrial buildings (51 references) - updated.
No. 7 Air flow through building entrances (22 references).
No. 8 Air infiltration in commercial buildings (28 references).
No. 9 Air infiltration in public buildings (10 references).
No. 10 CO_2 controlled ventilation (13 references).
No. 11 Occupancy effects on air infiltration (15 references).
No. 12 Windbreaks and shelter belts (30 references) - updated.
No. 13 Air infiltration measurement techniques (27 references).
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No. 15 Identification of air leakage paths (23 references).

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CONFERENCE PROCEEDINGS

No. 1 'Instrumentation and measuring techniques'.
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No. 2 'Building design for minimum air infiltration'.
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Unrestricted availability. Price: £23.50 sterling.
No. 4 'Air infiltration reduction in existing buildings'.
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