Air Infiltration Review

a quarterly newsletter from the IEA Air Infiltration and Ventilation Centre

Vol. 8, No. 3, May 1987

New Zealand Moisture Workshop

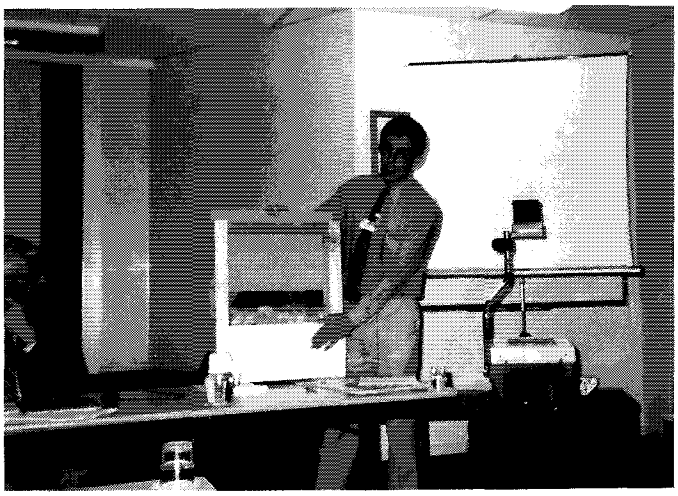
A total of ten countries were represented at the Air Infiltration and Ventilation Centre's Spring Steering Group Meeting and supporting Workshop held in Wellington, New Zealand, between 23-27 March 1987. This was the first opportunity for the Centre to meet in the southern hemisphere since New Zealand joined the AIVC in June 1982. The week began with a visit to the Building Research Association of New Zealand (BRANZ) where the director, Peter Foster, welcomed the Association's largest international gathering. Much of the work of BRANZ relating to air infiltration, air quality and building airtightness was on display with special reference to New Zealand's particular difficulty with moisture problems in buildings.

The Moisture Workshop itself was opened by Margaret Shields, New Zealand Associate Minister of Housing, who stated that condensation was a silent destroyer of New Zealand homes. In part this was due to life style combined with climate and poor ventilation. Harry Trethowen from BRANZ outlined the mechanism of moisture transport in New Zealand buildings. Of special concern was the transport of moisture from sub-floor level, through building cavities, to the roof space. He went on to state that structural moisture was not concerned with peak conditions but with average conditions. Additionally, vapour diffusion was rarely identified as a problem, the principal mechanism being that of airborne moisture transfer. Max Sherman from the Lawrence Berkeley Laboratory in California, USA, continued with the theme of attic ventilation and outlined a series of case studies in which roof insulation created condensation difficulties. He pointed out that in this particular study, 90% of the moisture came from the ventilation air with only 10% from the occupied space. A main problem was that of moisture storage and its subsequent release.

Tour of BRANZ Research Laboratory

Inside this issue:

Mark Bassett from BRANZ described observations of the direct transfer of rainwater through cladding materials which took place by means of high velocity air flow or driving rain. He showed that cladding material which may leak in isolation might, *in situ,* not cause a problem. This is because the pressure characteristics across cladding alter significantly with the main pressure difference being across the relatively impermeable inner wall lining.



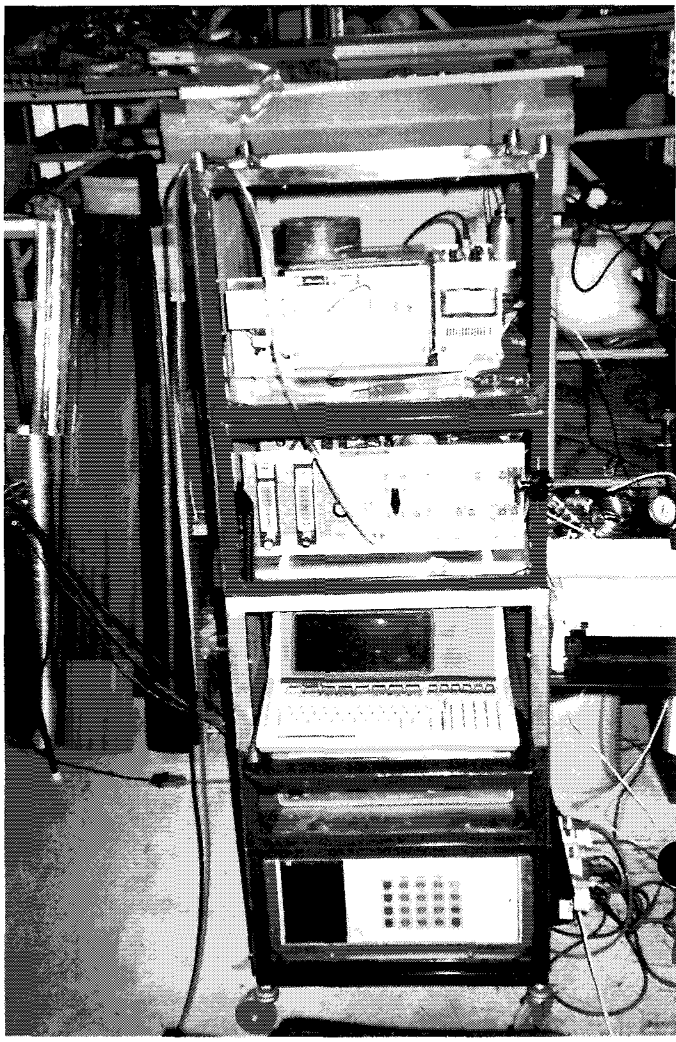
Mark Bassett (BRANZ) presents his paper 'Air flow resistances in timber-frame walls'

Willem de Gids from TNO Division of Technology for Society, Netherlands, analysed air and moisture flow in relation to the pattern of air flow. He also considered the influence of open windows and described the importance of analytical methods to analyse the pressure distribution and hence inter-room air flow characteristics. In considering moisture transfer, he emphasised the need to take into account the pattern of air movement and the activities of occupants. Malcolm Cunningham from BRANZ described in detail the use of an analogue electrical resistance model to analyse the behaviour of moisture. He described how the physics of moisture can be described by a time constant and that, for a given time constant, the long-term behaviour of any situation could be determined. Johnny Kronvall from Lund University, Sweden reviewed research into building moisture problems in Sweden. He illustrated a flow chart for design to avoid moisture and described the influence of poor ventilation in relation to building moisture. Jørn Brunsell from the Norwegian Building Research Institute went on to further describe the Scandinavian approach with special reference to the influence of climatic extremes and the penetration of moisture through cladding. He also illustrated a series of case studies in which building defects resulted in either mould growth or, in one instance, severe condensation.

Anthony Wilson from Oscar Faber Consulting Engineers in the UK reviewed Chapter A10 of the Chartered Institution of Building Services Engineers (CIBSE) Guide on moisture and the draft version of British Standard 5250. He said that an estimated 3.5 million homes in the United Kingdom suffer from some form of moisture problem and that some 8% of the population claim to suffer from moisture in the home.

Tony Bongard, from AHI Armafoil in New Zealand, is responsible for the practical answers to New Zealand moisture problems. He illustrated a series of case studies in which serious moisture problems had been identified and for which remedies had been formulated. Principal problems were ground moisture sources, avoidable problems such as design failures and other defects. He concluded that there was a need for the education of the building industry in matters related to moisture while the occupants of buildings should also be well informed.

John Shaw of the National Research Council, Canada, analysed the leakage performance of polyethylene vapour barriers. Sheets of vapour barrier were tested to destruction, to observe the performance of joints especially. John also described the performance of jointing techniques for vapour barriers. In the final presentation, Rob Bishop of BRANZ described the use of ventilation to reduce indoor condensation. He illustrated the importance of an optimum balance between heating and ventilation and also showed how natural ventilation could be applied to achieve the required ventilation rate.



Constant concentration tracer gas device as used at BRANZ

Proceedings and discussion notes are currently being compiled and will be published shortly in conjunction with a Technical Note on airborne moisture problems in buildings. Full details of availability will be published in the August edition of Air Infiltration Review.

Mechanical Ventilation Systems for Houses

C.Y. Shaw, National Research Council, Canada

Introduction

Adequate ventilation is essential for all houses to achieve an acceptable indoor air quality and humidity level and, in some cases, to ensure an adequate supply of combustion air for fuel-fired heating appliances. In the past, most houses were ventilated by air leakage through cracks and openings in the envelope. However, the demand for energy conservation in recent years has led to the construction of tighter new houses and the tightening of existing houses where air leakage can no longer be relied upon as the sole source of ventilation air. As a result, mechanical ventilation systems are required in these tight houses.

This article presents a brief description of the types of mechanical ventilation systems commonly installed for houses, and the effect of the operation of such a system on the house pressure and the performance of other appliances. It also presents a method for determining the air flow rate of the mechanical ventilation system required for winter operation, which takes advantage of the increased air infiltration in winter, and some guidelines for distributing the ventilation air effectively.

Mechanical Ventilation Systems

There are three basic types of mechanical ventilation system:

- 'balanced'
- supply-only
- exhaust-only

Balanced system

A 'balanced' system consists of a supply fan which draws the outdoor air into the house and an exhaust fan which is supposed to exhaust an equal amount of indoor air to the outdoors. In actual installations, the supply and the exhaust air flows are rarely equal because no attempt is made to adjust the supply air flow rate to account for varying outdoor air density. For this reason alone, the supply air flow rate in winter can be as much as 20% greater than that in summer while the exhaust air flow rate remains virtually unchanged.

In recent years, Heat Recovery Ventilators (HRV) have been installed in many houses in place of conventional 'balanced' systems. Such a device consists of a supply fan, an exhaust fan and an air-to-air heat exchanger. It serves a dual function of supplying ventilation air and reducing the cost of heating the ventilation air. It should be pointed out that a 'balanced' system does not need a heat exchanger to work properly. The sole function of a heat exchanger is to save energy by supplementing the energy required to heat the ventilation air with the heat recovered from the exhaust air. The choice of heat recovery ventilator over a conventional 'balanced' system, therefore, depends on the availability of the device, the cost of having the heat recovery option, the energy saving capacity, and the current and future costs of energy.

Supply-only and exhaust-only systems

A supply-only system consists of a supply fan to bring the outdoor air into a house. The indoor air leaks out of the house through cracks and openings in the envelope. An exhaust-only system consists of an exhaust fan to exhaust the indoor air to the outdoors. The make-up air from the outdoors leaks in through the envelope. Houses with a supply-only system are more susceptible to condensation problems than those with other systems, because the exfiltration of the warm and humid indoor air in these houses occurs mainly through unintentional leakage paths in the envelope. For this reason, a supply-only system is not recommended.

The choice is therefore essentially between a 'balanced' system and an exhaust-only system. Normally, a 'balanced' system is particularly suitable for houses with fireplaces, fuel-fired heating appliances, and also for houses with sources of radon and other contaminants in the building structure. Otherwise, because of its low cost, an exhaust-only system would be preferable.

Interaction Between Mechanical Ventilation System and House

As houses cannot be built completely airtight, air infiltration occurs whenever pressure differences are caused by wind or an inside-outside temperature difference. The ventilation air, therefore, includes both the outdoor air supplied by mechanical ventilation systems and air infiltration; both these components are weather dependent. Measurements made on a two-storey house with a 'balanced' system indicate that the ventilation air supply rate increases as the outdoor air temperature decreases. The ventilation air supply rate also increases with the wind speed, but for cities with cold climates like Ottawa, the effect of wind would be masked by the large inside-outside temperature difference during the winter months. Thus, for wind speeds less than 30 km/h and temperature differences greater than 15 K, the ventilation air supply in a house with a 'balanced' system is primarily a function of temperature difference alone.[1]

Measurements on a similar house with an exhaust-only system indicate that the ventilation air supply rate is relatively insensitive to both wind and temperature difference and remains essentially constant.[1] This is especially true for a system with a high exhaust rate.

Figure 1 shows the contributions of air infiltration, mechanical ventilation system and chimneys to the ventilation air supply of a two-storey house, as measured on a calm day with an indoor-outdoor temperature difference of 28 K. With no mechanical ventilation (Figure 1a), the outdoor air pressure was greater than the indoor pressure at the lower levels and the reverse was the case at the upper levels of the house. At a level slightly above the floor level of the second storey, the interior and exterior pressures were equal. This level is called the neutral pressure level. Below this level, air infiltration occurs, and above it, air exfiltration occurs. The ventilation air was supplied by air infiltration alone at a rate of 0.25 ac/h. With a 'balanced' system delivering an air flow rate of 0.5 ac/h (Figure 1b), the ventilation air rate increased to about 0.7 ac/h. The pressure pattern was similar to that without the mechanical ventilation system. With an exhaust-only system (Figure 1c), the ventilation air rate was equal to the exhaust rate of 0.5 ac/h and the neutral pressure level was located at the ceiling level of the top storey. There was essentially no air exfiltration through the envelope.

Figure 1d shows the same house with a chimney. It indicates that, similar to an exhaust-only system, the presence of a chimney moved the neutral pressure level upwards to somewhere near the middle of the second storey, resulting in an increase in the ventilation rate from 0.25 to 0.3 ac/h. If a 'balanced' system were added, the ventilation air supply rate would increase but the house pressure, and hence the venting capacity of the chimney, would not be significantly affected.

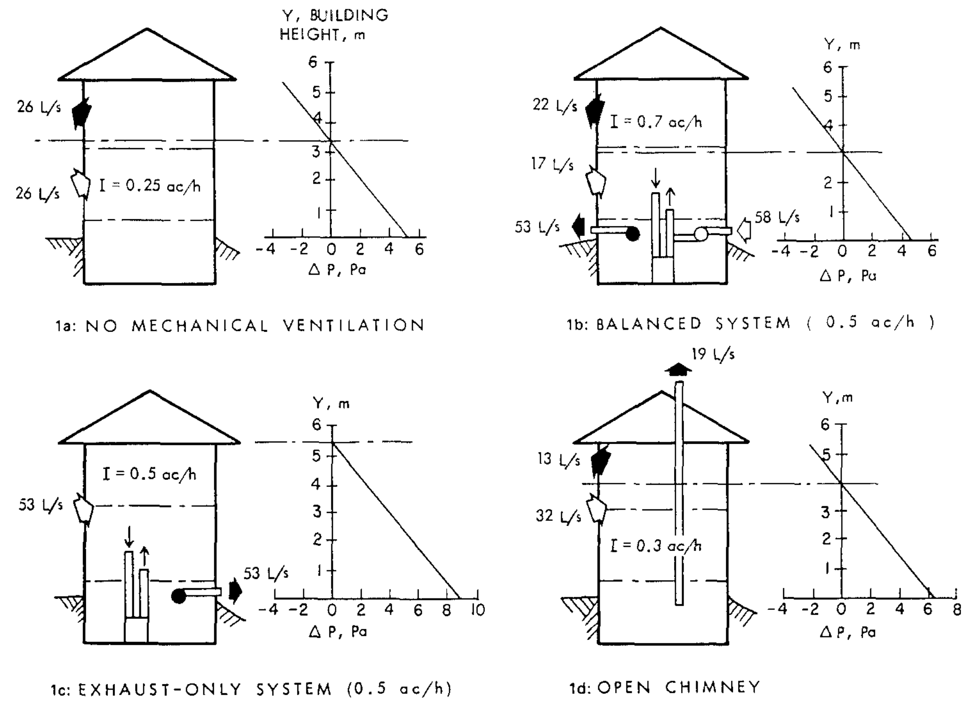


Figure 1: Air flow pressure patterns induced by temperature difference, chimney and mechanical ventilation systems.

With an exhaust-only system, the neutral pressure level would move upwards, causing a reduction in the house pressure and also in the venting capacity of the chimney. The effect of chimneys annd exhaust fans on the ventilation air supply and house pressure is further illustrated in Figure 2. Two different types of chimney were studied: a 12.7 cm open chimney of a conventional gas furnace and an 8 cm wall mounted exhaust vent of a medium efficiency induced draught gas furnace. The results indicate that the amount of outdoor air leaking into the house increases linearly with the neutral pressure level as the house pressure decreases due to the operation of a chimney or an exhaust fan. This linear relationship is expected to be valid until the neutral pressure level reaches the ceiling level of the top storey. In the region slightly above the ceiling level, a sharp increase in the air leakage occurs due to the increased pressure difference across the ceiling where a significant proportion of leakage openings is located. As the exhaust air flow rate of the fan further increases, the pressure difference across the house envelope depends only on the exhaust fan. The amount of outdoor air leaking into the house varies with the nth power of the fan induced pressure difference. Figure 2 also indicates that the gas flow through the chimney of the conventional gas furnace decreases slowly as the fan exhaust rate increases and the neutral pressure level moves upwards. Measurements indicated that the chimney backdraught occurred when the neutral pressure level reached approximately seven times the building height above ground level.

If the furnace is not operating and the chimney is cold, backdraught can occur in the chimney as soon as the neutral pressure level reaches approximately the top of the chimney. For design purposes, therefore, the ceiling level of the top storey would be a reasonable choice as the maximum acceptable height of the neutral pressure level for satisfactory chimney venting and for sizing exhaust-only systems.

Sizing Mechanical Ventilation Systems

The capacity of a mechanical ventilation system should be determined on the basis of the design ventilation rate and the air infiltration rate. However, in practice air infiltration is rarely considered because it is difficult to estimate. As a result, the amount of ventilation air received by a house under the combination of mechanical ventilation and air infiltration often exceeds the design ventilation rate, causing an unnecessary increase in energy consumption. The energy consequence is not serious under mild weather conditions because temperature differences are small. This is not the case under winter conditions. For a house with a 0.5 ac/h 'balanced' system and an air infiltration rate of 0.25 ac/h, Figure 1b shows that the amount of ventilation air received by the house can exceed the air flow rate of the mechanical ventilation system by as much as 40%.

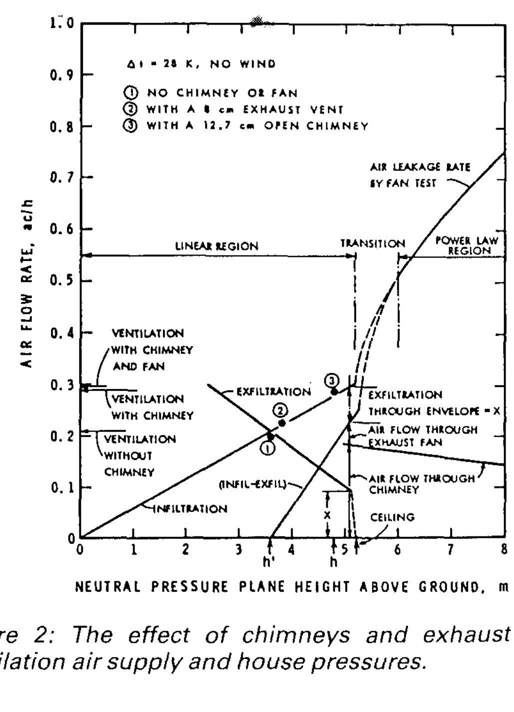


Figure 2: The effect of chimneys and exhaust fans on ventilation air supply and house pressures.

On one hand, to satisfy the ventilation requirement, a mechanical ventilation system should always be capable of delivering the design ventilation rate. On the other hand, to conserve energy, it should be operated under a reduced flow during the winter months to take advantage of the increased air infiltration. Thus, it is suggested that all mechanical ventilation systems be equipped with a flow controller such as a two-speed fan, and operate continuously with the reduced capacity designed for the winter months. A manual switch and/or an indoor humidistat can be used to increase the flow for the quick removal of odours, moisture and fumes during cooking, bathing and cleaning. In addition, an outdoor temperature controller may also be installed to increase the air flow in milder weather.

Air flow rate for winter operation

The air flow rate for winter operation can be determined on the basis of the design ventilation rate and the mean air infiltration rate for the winter months. The recommended design ventilation rate for houses can be found in various standards such as the ASHRAE Standard 62-1981.[2] For typical houses an outdoor air supply rate of 0.5 ac/h would be a reasonable value for the time being. This value has been reduced to 0.35 ac/h in the revised ASHRAE standard to be published shortly.

The mean air infiltration rate for the winter months is proportional to the airtightness of the house which can best be determined by conducting a fan pressurization test. Based on the measurements of 40 houses,[1,3] the range of airtightness values for different types of low energy houses is given in Table 1.

Types	Rating	Air Changes Per @ 10 Pa
Bungalow	Tight	0.13
	Average	0.43
	Loose	0.73
Two-storey	Tight	0.17
	Average	1.05
	Loose	1.93
Others	Tight	0.16
	Average	0.49
	Loose	0.81

Table 1: Range of airtightness values for low energy houses.

Based on the mean air infiltration rate for the winter months estimated from the airtightness value, the air flow rate for the winter operation of a balanced system and an exhaust-only system can be determined from Figures 3a and 3b respectively for various design ventilation rates. Figure 3b also shows the maximum allowable air flow rate for houses with chimneys. If a greater air flow rate is needed, intake openings must be installed in the exterior walls to avoid the possible occurrence of chimney backdraught. Such a remedial measure contradicts the purpose of tightening houses but it is a practical and inexpensive method of providing and distributing the ventilation air to the needed areas for some houses. The optimum degrees of airtightness for new and existing houses have yet to be determined.

Air Distribution

In spite of an adequate supply of ventilation air for the whole house, there can be a room or rooms where the ventilation air is inadequate, because of poor air distribution. For houses with a forced air heating system, the most effective and economical way of distributing the ventilation air is to use the existing air distribution system. This can best be achieved by connecting the supply air duct of a 'balanced' system to the return duct of the forced air heating system (if *such an installation is permitted by the prevailing building* codes and standards). Otherwise, the supply duct should be terminated near a main return air grille of the forced air heating system. For houses without forced air heating systems, an air distribution network might be necessary for a 'balanced' system. An alternative would be to use an exhaust-only system with intake openings installed in the exterior wall of the areas requiring the proper distribution of outdoor air.

References

1. Shaw, C.Y.
   Methods for estimating air change rates and sizing mechanical ventilation systems for houses.
   Institute for Research in Construction, NRC, BRN 237, 1985.

2. ASHRAE Standard 62-1981.
   Ventilation for acceptable indoor air quality.
   ASHRAE, 1981.

3. Dumont, R.S, Orr, H.W. and Figley, D.A.
   Airtightness measurements of detached houses in the Saskatoon area.
   Institute for Research in Construction, NRC, BRN 178, 1981.

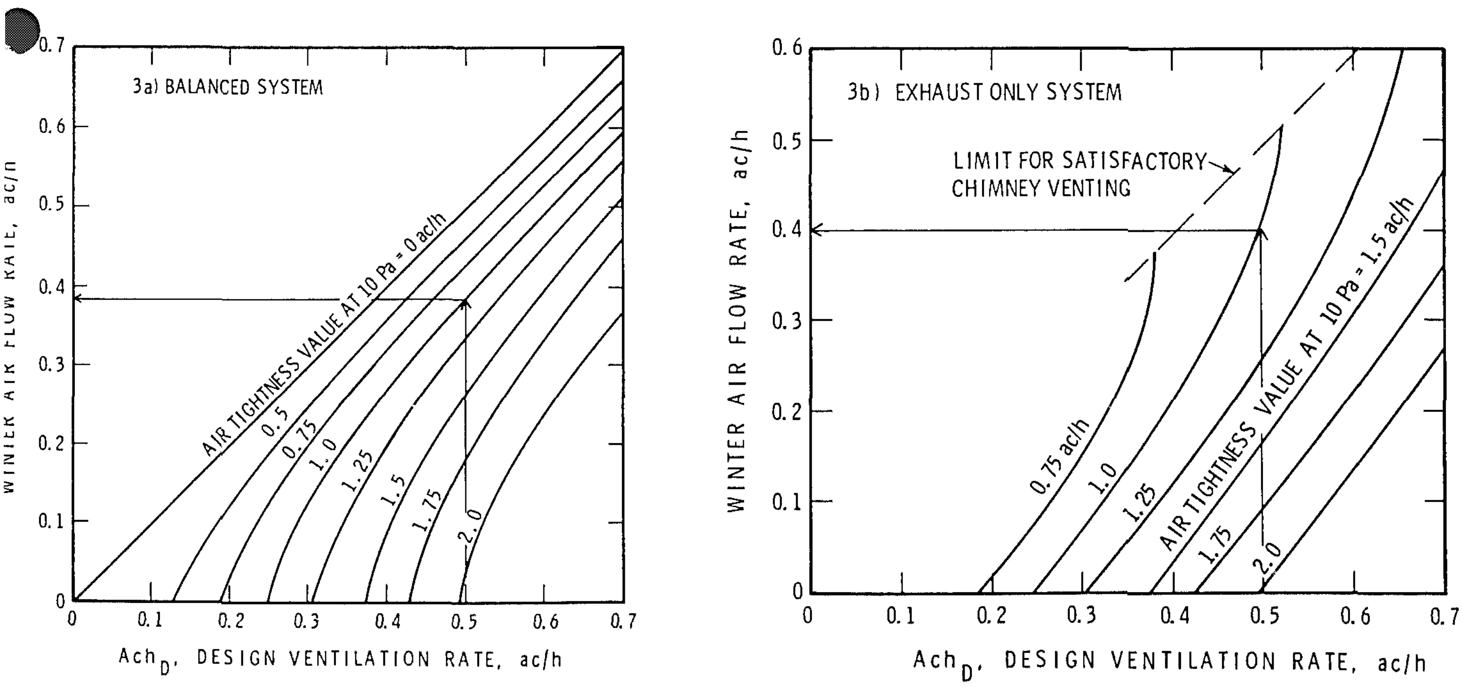


Figure 3: Air flow rate of a mechanical ventilation system required for winter operation.

The Use of Detector Tubes with Carbon Dioxide as a Tracer Gas

M. Sandberg and J. Sundberg
The National Swedish Institute for Building Research

Introduction

Tracer gas concentrations are often analysed by using infra-red spectroscopy. Infra-red gas analysers have a fast response time and are accurate. However, this type of instrumentation is relatively expensive and can only be used for this type of measurement. A cheaper alternative is therefore preferred.

Normally there is a trade-off between cost and accuracy. Detector tubes are inexpensive and are available for many gases, among them CO_2. They are packed with a selective solid absorbent which gives a colour reaction with the gas in question. The higher the concentration of gas which enters the tube the further the coloured region extends down the packing. The tubes have approximate calibration markings which show the concentration of the gas.

This article reports a method of measuring the ventilation air flow rate using a tracer decay technique in occupied houses with CO_2 as a tracer gas. The metabolic CO_2 from people is taken into account. The accuracy of the method has been explored through various tests.

Theory

Consider a room with complete mixing of both the outdoor air supplied, q, and the tracer gas released in the room. The equation of continuity gives the following well known expression for the tracer gas concentration C(t) in a room with volume V:

$$V dC(t)/dt = -q[C(t) - C_b] + m(t) \qquad (1)$$

where C_b = background concentration

t = time

m = production rate of CO_2 from people

It is assumed that q is time-independent and, after integrating equation (1) from 0 to T_m (the total measuring period), the following is obtained

$$q = V[C(O) - C(T_m) + \int_O^{T_m} \frac{m(t)}{V} dt] / (\int_O^{T_m} (C(t) - C_b) dt) \qquad (2)$$

If it is assumed that the production rate of CO_2 from people is constant, then equation (2) may be written as

$$q = V[C(O) - C(T_m) + \frac{mT_m}{V}] / (\int_O^{T_m} (C(t) - C_b)\, dt) \qquad (3)$$

If n samples of the concentration are taken with the same period, $\triangle t$, between each sample, then the integral in (3) can be calculated as

$$\int_O^{T_m} (C(t) - C_b) dt = 0.5(C_1 + C_n) \triangle t + \sum_{i=2}^{n-1} C_i \triangle t \qquad (4)$$

Measurements

All the tests reported in this article were carried out in an indoor test house (volume 175.7 m3) (see references 1 and 2). During all the tests the house was ventilated by a mechanical extract system. The air was extracted from the kitchen and bathroom and the intake of air was through openings in the living room and bedroom. The extract flow rates were measured to an accuracy of between 2–3% with orifice plates. The carbon dioxide concentrations were recorded both with detector tubes (manufactured by Dräger) and an infra-red gas analyser (manufactured by Leybold-Hereus, Binos type analyser). In each test the concentration was recorded in the living room. The tests were carried out at two flow rates. For each flow rate, tests were made with the house unoccupied and with one or two persons in the house. The tests started by releasing carbon dioxide to an initial concentration of about 2000 ppm and the number of samples, n, taken with the detector tubes amounting to about 5. During the whole measuring period small mixing fans were in operation.

Figure 1: CO_2 Dräger tube and sample bellows

Figure 2 shows an example of the concentrations recorded in one test. The dashed line represents the exponential decay of concentration which can be expected with no production of carbon dioxide and complete mixing. The decay is far from exponential and it is therefore not possible to utilize the slope of the decay curve to estimate the flow rate of air. Instead the flow rate, q, is determined by applying equations (3) and (4).

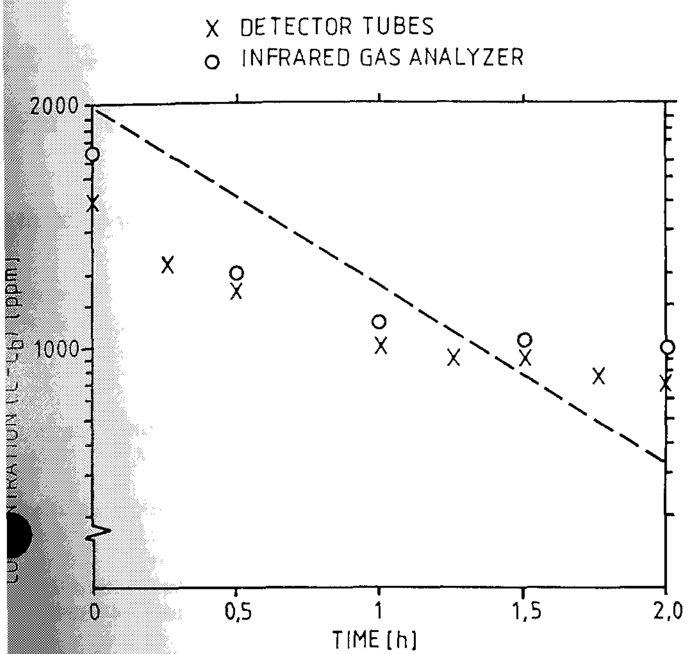


Figure 2: Examples of recorded concentrations

The results from all tests are compiled in Table 1. The flow rate is given as the specific flow rate expressed in house volumes per hour. The production rate of carbon dioxide was set to 0.35 litres per minute per person.

The accuracy of the method is quite high and the errors are of the same order of magnitude as the standard decay technique. In these tests an unfavourable location had been chosen for the sampling point, i.e. the living room. It would be better to sample in a room where the main part of the air leaves the house, which should give better accuracy.

	NOMINAL FLOW RATE (house volumes/h)	MEASURED FLOW RATE Infrared gas analyzer	Detector tubes
UNOCCUPIED	0.54	0.58±0.15 (17 %)	0.52 (-4 %)
	0.96	0.88 (-8 %)	0.79 (-17 %)
ONE PERSON IN THE LIVING ROOM	0.54	0.55 (2 %)	0.50 (-7 %)
	0.96	1.02 (+7 %)	0.87 (-8 %)
ONE PERSON IN THE SLEEPING ROOM	0.54	0.57 (+5 %)	0.51 (-5 %)
	0.96	1.02 (+7 %)	0.89 (6 %)
TWO PERSONS IN THE HOUSE	0.54	0.57 (+6 %)	0.44 (-18 %)
	0.96	1.22 (+27 %)	1.12 (+17 %)

Table 1: Results (the relative error of the measured flow rate is given in brackets)

Conclusions

By using the area under the decay curve it is possible, when the release rate of metabolic CO_2 from people is constant and known, to estimate the flow rate of outdoor air entering an unoccupied house.

References

1. Sandberg, M.
An indoor test house
Air Infiltration Review, Vol. 6 No. 1, November 1984.

2. Sandberg, M. and Blomqvist, C.
A quantitative estimate of the accuracy of tracer gas methods for the determination of the ventilation flow rate in buildings.
Building and Environment, Vol. 20 No. 3, 1985.

COMIS – A Joint Research Effort at the Lawrence Berkeley Laboratory

The Energy Performance of Buildings Group at Lawrence Berkeley Laboratory (LBL) is investigating the possibility of hosting a one-year joint reseach effort to develop a multizone infiltration model commencing October 1, 1988. The task for the workshop (Conjunction of Multizone Infiltration Specialists (COMIS)) would be to develop a detailed multizone infiltration program taking crack flow, HVAC-systems, single-sided ventilation and transport through large openings into account. Multigas tracer measurements and wind tunnel data would be used to validate the model. The agenda integrates all participants' contributions into a single model containing a large library of modules. The user-friendly, PC-based program would have different levels of support and would be aimed at building professionals.

This year-long effort would enable LBL to develop the model, perform the validation and produce a user handbook. They plan to invite interested colleagues to participate in this research effort. As the host, LBL would supply the work space, computer time and limited clerical support. Researchers participating in this workshop must receive complete financial support from their home institutions/countries. LBL feel that countries with infiltration/ventilation research ought to be in favour of this workshop, as this joint effort would supply an advanced program to all participating institutions at the cost of only one man-year each.

Interested researchers should contact LBL as soon as possible at the following address.

Helmut E. Feustel
Lawrence Berkeley Laboratory
Building 90, Room 3074
Berkeley
CA 94720, USA

8th AIVC Conference :

Ventilation Technology

21 – 24 Se

Park Hotel St. Leonhard, Überlin

This conference will focus on recent developments in the application of air infiltration research. The following key areas of particular importance will be covered:

- calculation techniques
- measurement techniques
- building construction in relation to air infiltration and air quality
- airborne moisture problems

Papers will be presented by authors from 12 countries and one evening will be devoted to a poster session with contributions from 16 presenters.

A technical visit has also been included in the programme and delegates will be invited to join the tour of the ventilation facilities in a convention hall (the Graf Zeppelin House) and the Zeppelin Museum.

Registration forms with complete programme and venue details are available from your Steering Group representative (see back cover of this newsletter) or direct from the Air Infiltration and Ventilation Centre (contact Jenny Elmer on Tel: 0344 53123, Tlx: 848288 BSRIAC G, Fax: 0344 487575).

Registration fee, including three nights inclusive accommodation, copy of conference proceedings, conference dinner, transport and technical visit, is £270 sterling (£230 sterling (double occupancy), i.e. adjoining rooms/shared facilities). Final date for receipt of registration forms is 24th August 1987.

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

Programme

Monday 21 September 1987

11.00	Departure of coach from Zurich Airport, Switzerland	
13.00	Arrival at conference venue/ registration/lunch	
14.30	Keynote Address	H. Hlawiczka (Fed.Rep. Germany)
	Measurement techniques for air infiltration and air leakage	P. Charlesworth (United Kingdom)
	Measurements of infiltration and air movement in five large single-cell buildings	G.V. Lawrance et al (United Kingdom)
16.00	Afternoon tea	
16.30	Evaluation through field measurements of BNL/AIMS, a multiple tracer gas technique for determining air infiltration rates	N. Bergsoe et al (Denmark)
	Development of a multi tracer gas system for measurement of interzonal air flows in buildings	J. Littler et al (United Kingdom)
	Simple technique for measuring infiltration and ventilation rates in large and complete buildings: protocol and measurements	M. Perera et al (United Kingdom)
	Field study comparisons of constant concentration and PFT infiltration measurements	D. Bohac et al (USA)
19.30	Reception	
20.00	Conference Dinner	

Tuesday 22 September 1987

09.00	The use of tracer gas techniques in commercial building ventilation studies	D. Wortman et al (USA)
	Tracer gas used to evaluate HVAC equipment	B. Kvisgaard et al (Denmark)
10.00	Morning coffee	
10.30	Appliance of thermography at air leakage measurements	O. Adan et al (Netherlands)
	The effect of vapour barrier thickness on airtightness	J. Brunsell (Norway)
	Draught measurement in ventilated and non-ventilated buildings	E. Mayer (Fed. Rep. Germany)
12.30	Lunch	
13.30	Data needs for the purpose of air infiltration computer code validation	J. Scartezzini et al (Switzerland and USA)
	Simulation of CO2 concentration for determining the air change rate	T. Baumgartner (Switzerland)
15.00	Technical visit	
19.30	Dinner	
21.30	Free evening	

Wednesday 23 September 1987

08.30	Estimation of air infiltration in multi-storey buildings using wind tunnel tests	P. Grabau et al (Canada)
	Building pressure distribution data correlations	S. Chandra et al (USA)

Details and Programme

Research and Application

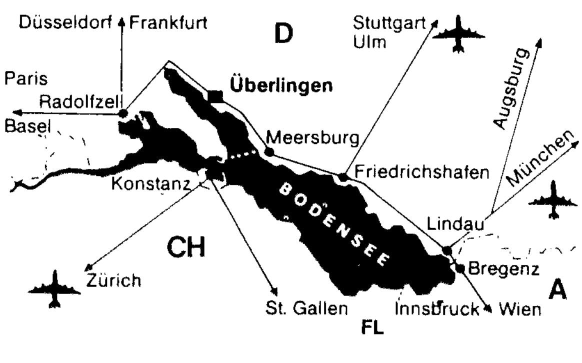
ember 1987

en, Federal Republic of Germany

	Applications of a simplified model for predicting air flows in multi-zone structures	T. Haugen et al (Norway and USA)
10.00	Morning coffee	
10.30	Use of statistics for predicting distribution of air infiltration	A. Nielsen (Norway)
	Thermal coupling of leakage flows and heating load of buildings	R. Kohonen et al (Finland)
	Ventilation rates and energy losses due to window opening behaviour	P. Wouters et al (Belgium, UK and Netherlands)
12.30	Lunch	
14.00	Free afternoon	
19.00	Dinner	
20.00	Poster session:	
Poster 1:	The use of modified constant concentration techniques to measure infiltration and inter-zone air flow rates	D. Bohac et al (USA)
Poster 2:	Measurement of seasonal air flow rates in an unoccupied single family house	D. Harrje et al (USA)
Poster 3:	A portable unit for measuring ventilation efficiency	N. Breum (Denmark)
Poster 4:	Micro-computer-aided measurement of air exchange rates	F. Heidt et al (Fed.Rep. Germany)
Poster 5:	Ventilation and leakage measurements in industrial buildings	J. Lilly (United Kingdom)
Poster 6:	The influence of temperature variation on stack effect in high-rise buildings	Y. Lee et al (Canada)
Poster 7:	Displacement ventilation	P. Danielsson et al (Sweden)
Poster 8:	Airtightness of masonry walls	J. Lecompte (Belgium)
Poster 9:	A study of the drying potential of various wood-frame wall systems used in Atlantic Canada	L. McCuaig et al (Canada)
Poster 10:	Airborne moisture in timber-framed buildings	G. Valentine et al (United Kingdom)
Poster 11:	Ventilation effectiveness and clearance rates for particulate matter	G. Lundgvist (Denmark)
Poster 12	Building codes designed for ensuring good indoor air quality	R. Ferahian (Canada)
Poster 13	Applications of a compensating flow measurement device	J. Phaff et al (Netherlands)
Poster 14:	The development of models for the prediction of indoor air quality in buildings	R. Grot et al (USA)
Poster 15:	AIRDEX: An expert system to diagnose moisture problems	A. Persily (USA)
Poster 16:	Expert system for moisture problems in buildings	H. Trethowan (New Zealand)
Poster 17:	The importance of wind barriers for insulated wooden constructions	S. Uvsløkk (Norway)
22.30	Close of session	

Thursday 24 September 1987

08.30	The moisture load in dwellings as a function of the layout of the rooms shown by ground plans	H. Trumper et al (Fed.Rep. Germany)
	Ventilation, heat and moisture in attics. A parameter study on year's basis	J. Kronvall (Sweden)
	Prevention of moisture damage by ventilation of the foundation	L-E. Harderup et al (Sweden)
10.00	Morning coffee	
10.30	Ventilation requirements and demand-controlled ventilation	L. Trepte (Fed.Rep Germany)
	An overview of the R-2000 home programme	M. Riley et al (Canada)
	Design, construction and performance of a dynamic wall house	J. Timusk (Canada)
12.00	Discussion and summing-up	
13.00	Lunch	
14.30	Coach returns to Zurich Airport, Switzerland	
16.00	Coach arrives at Zurich Airport, Switzerland	



Book Review

Controlling Airborne Contaminants in the Workplace British Occupational Hygiene Society Technical Guide No. 7

BOHS Technical Committee,
Working Group on Ventilation Design
H & H Scientific Consultants Limited,
Leeds, UK, 1987

The Guide is written as an aid to hygienists and others responsible for, or interested in, the control of exposure to air contaminants in the workplace. It concentrates on the control of toxic substances and does not, in the main text, deal with control of flammable or explosive hazards.

The Guide sets out the basic outlines of good design and administrative principles, identifies common misconceptions and errors in design and points the reader to other more detailed texts and references. Although ventilation design is covered in more detail, the early chapters emphasise the importance of careful study of processes and how exposure occurs, before ventilation systems are designed and installed. The reader is therefore encouraged to read the early chapters before proceeding to the material on ventilation.

In order to supplement the information supplied in the Guide, the BOHS Working Party intends to publish a series of case studies on the control of air contaminants.

The size of the risk that is run by people exposed to hazardous materials is determined firstly by the toxic properties of the material and secondly by the degree of exposure. This in turn is determined by the effectiveness of the methods used to control exposure. If the methods applied are difficult to use or unreliable, then excessive exposure may occur and the health and well-being of those relying on the control methods may suffer. If the methods applied are efficient but not cost-effective then, although adequate control is realised, they may be carried out at undue cost.

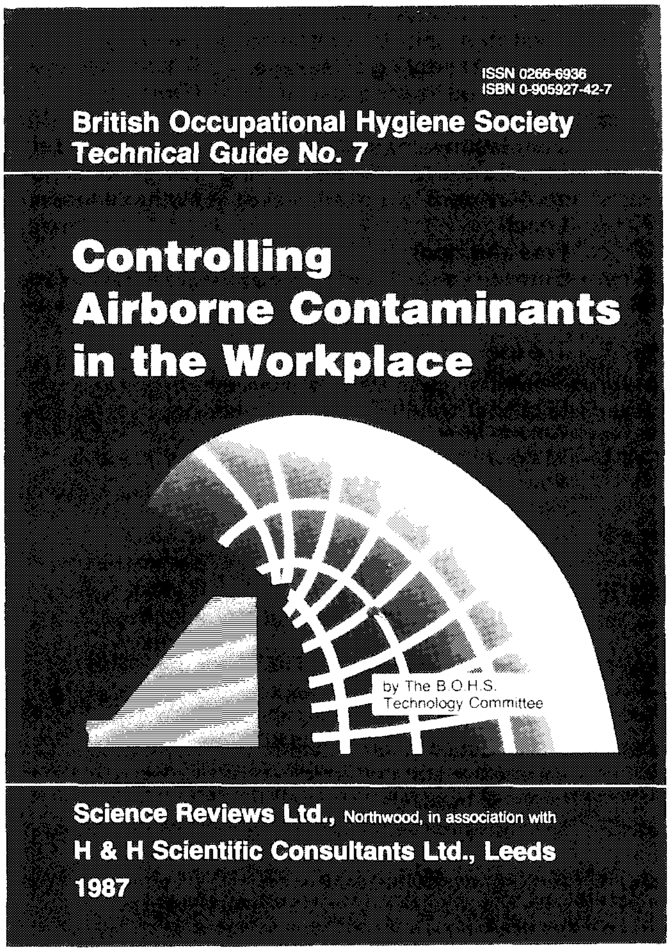
The emphasis of the Guide is to link exhaust ventilation design to hygiene measurements of exposure.

The report is divided into 12 sections:

- Introduction
- Management of air contaminant control
- Examining processes and understanding exposure
- Designing to control exposure
- Non-ventilation methods of control
- The costs of ventilation
- Enclosures and other receiving hoods
- Captor hoods
- General ventilation and air jets
- Ventilation hardware and system design
- Common problems, commissioning and maintenance
- Annotated bibliography

The annotated bibliography is divided into sub-sections which include:

- Process information
- General tests on ventilation
- Publications produced by specific organisations
- References in hygiene journals and a useful section listing relevant computerised databases



Four appendices include case studies in Air Contaminant Control and a list of useful organisations and addresses.

Copies of the Guide are available from:

Science Reviews Limited
PO Box MT27
Leeds
LS17 8QP
United Kingdom
Tel: (0532) 687189

Price: £18.00 + £1.00 p+p
US$ 36.00 + $2.00 p+p

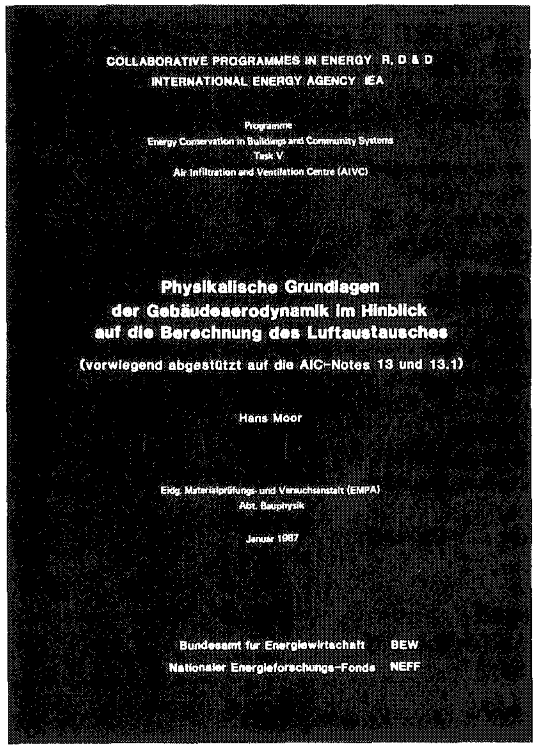
AIVC Technical Notes 13 and 13.1* now available in German ...

The Centre's Wind Pressure Review and Workshop proceedings are now available translated into German. This publication, entitled 'Physikalische Grundlagen der Gebäudeaerdynamik im Hinblick auf die Berechnung des Luftaustausches' by Dr. Hans Moor, is available, price 25 Swiss Francs, direct from

Dr. P. Hartmann
Building Physics Section
EMPA
CH 8600 Duebendorf
Switzerland
Price: 25 Swiss francs

*AIC-TN-13-84 Allen, C.
Wind Pressure Data Requirements for Air Infiltration Calculations

AIC-TN-13.1-84 Allen, C.
1984 Wind Pressure Workshop Proceedings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Air Infiltration and Ventilation Centre (AIVC)

Physikalische Grundlagen der Gebäudeaerodynamik im Hinblick auf die Berechnung des Luftaustausches

(vorwiegend abgestützt auf die AIC-Notes 13 und 13.1)

Hans Moor

Eidg. Materialprüfungs- und Versuchsanstalt (EMPA)
Abt. Bauphysik

Januar 1987

Bundesamt für Energiewirtschaft BEW
Nationaler Energieforschungs-Fonds NEFF

Air Infiltration Review – Contributions Welcome

Air Infiltration Review has a quarterly circulation of 3,500 copies and is currently distributed to organisations interested in air infiltration and indoor air quality research, in 38 countries. Short articles, technical notes or correspondence relating to air infiltration or indoor air quality are required for possible inclusion in AIR.

Articles intended for publication should be approximately 1,000 words in length, They should also contain two or three diagrams or photographs highlighting the main theme of the text, and the graphical presentation of results is desirable.

Contributions will be welcome from participating and non-participating countries alike. If you wish to submit an article, or require an further help or information, please contact Jenny Elmer at the Air Infiltration and Ventilation Centre.

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Forthcoming Conferences

1. Building Climatology '87
   2nd International Symposium on New Developments in Building Climatology
   12–15 May 1987
   Moscow, USSR

   Further details from:

   Research Institute for Building Physics
   Gosstroy USSR
   Pushkinskaya st 26
   Moscow, 103828
   USSR
   Tel: 448 78 90

2. Roomvent '87
   Air Distribution in Ventilated Spaces
   International Conference at the Royal Institute of Technology
   10–12 June 1987
   Stockholm, Sweden

   Further details from:

   GLSM
   Box 5506
   S-114 85 Stockholm
   Sweden

3. ASHRAE Annual Meeting 1987
   Opryland Hotel, Nashville, Tennessee, USA
   28 June – 1 July 1987

   Further details from:

   Judy Marshall
   ASHRAE
   1791, Tullie Circle NE
   Atlanta
   GA 30329
   USA

4. Indoor Air '87
   Berlin (West), Germany
   17–21 August 1987

   Further details from:

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

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

   Further information from:

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

7. VVS & Indoor Clima 87
   Gothenburg, Sweden
   23–28 October 1987

   Further details from:

   HEVAC Technical Association
   and The Swedish Trade Fair
   PO Box 5222
   S-402-24 Gothenburg
   Tel: 46-31 200 000
   Telex: 20 600
   Telefax: 46-31 160 330

8. HVAC-DAYS – VVS DAGENE
   Sjolyst Centre, Oslo, Norway
   28–31 October 1987

   Further details from

   Skarland Press A/S
   PO Box 5042
   Maj 0301 Oslo 3
   Norway
   Telefax: (02) 60 36 50
   Tel: (02) 60 13 90

9. Healthy Buildings '88
   CTB Conference –
   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

5. 8th AIVC Conference
   Ventilation Technology – Research and Application
   Park Hotel St. Leonhard, Uberlingen, Federal Republic of Germany
   21–24 September 1987

   Further details from:

   Mrs J. Elmer
   Air Infiltration and Ventilation Centre
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   Bracknell
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Great Britain

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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.*

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.*

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'AIRGLOSS: Air Infiltration Glossary (English-German/Deutsch-Englisch) Supplement'
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AIC-TN-5.2-84 – Allen, C.
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AIC-TN-5.3-84
'AIRGLOSS: Air Infiltration Glossary (Italian Edition)'
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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 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.
'A subject analysis of the AIC's bibliographic database – *AIRBASE*.' 4th Edition
Comprehensive register of published information on air infiltration and associated subjects. The articles are indexed by subject and full bibliographic details of the 2,000 papers are given. A list of principal authors is also included. *Available free-of-charge to participating countries* only.*

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.*

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

No. 1 Pressurization – Infiltration Correlation: 1. Models (17 references).
No. 2 Pressurization – Infiltration Correlation: 2. Measurements (26 references).
No. 3 Weatherstripping windows and doors (24 references).
No. 4 Caulks and sealants (24 references).
No. 5 Domestic air-to-air heat exchangers (25 references).
No. 6 Air infiltration in industrial buildings (42 references).
No. 7 Air flow through building entrances (22 references).
No. 8 Air infiltration in commercial buildings (28 references).
No. 9 Air infiltration in public buildings (10 references).
No. 10 CO_2 controlled ventilation (13 references).
No. 11 Occupancy effects on air infiltration (15 references).
No. 12 Windbreaks and shelter belts (19 references).
No. 13 Air infiltration measurement techniques (27 references).
No. 14 Roofs and attics (34 references).
No. 15 Identification of air leakage paths (23 references).

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CONFERENCE PROCEEDINGS

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

Please note that the proceedings of AIVC conferences numbers 1-6 are now also available in microfiche form, price £75.00 per set.

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