Air Infiltration Review

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4TH AIC CONFERENCE 'Air infiltration reduction in existing buildings'

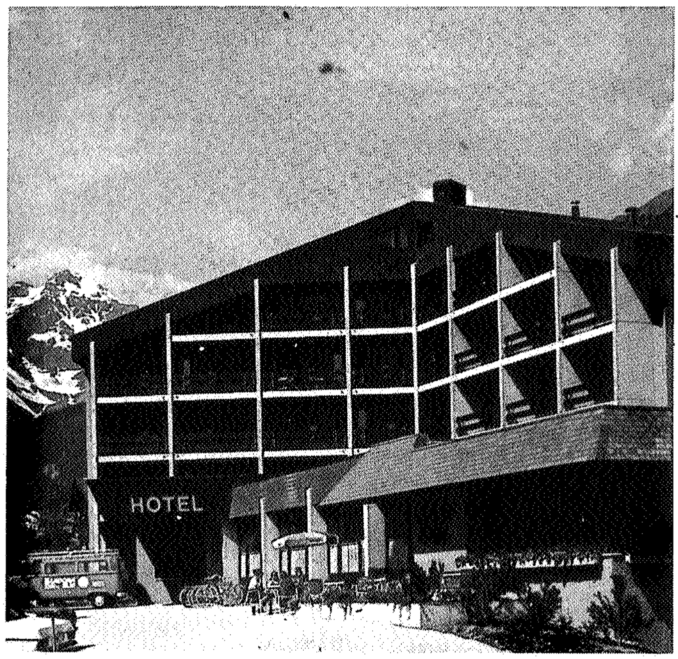
Monday 26 to Wednesday 28 September 1983 at Hotel Sardona, Elm, Switzerland

As previously announced, this Conference will focus on the effective treatment of existing buildings to reduce their air infiltration and so save energy. There will be sessions on industrial buildings (4 papers), commercial/institutional buildings (5 papers) and dwellings/residential buildings (5 papers). As well as three general papers, the programme will also include an informal session on recent developments in instrumentation and measurement techniques.

The Conference will be relevant to researchers, designers and building managers alike but attendance will be limited to about 40 delegates so promoting free and detailed technical interchange.

The Conference fee will be £145, inclusive of accommodation (2 nights), meals during the Conference period (Monday lunchtime to Wednesday afternoon) and transport to and from Zurich.

To be sure that you are included in this opportunity to keep up-to-date with developments in infiltration technology while enjoying the refreshing atmosphere of the Swiss Alps, please apply for a copy of the programme and booking form to either your Steering Group representative or AIC direct (see back page for addresses).



Main subjects in this issue:

The Choice of Airtightness and Ventilation System for Single Family Houses

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Introduction

Since 1973 research and development work has been going on in Sweden concerning the airtightness and ventilation of buildings. The rules of the Swedish Building Code (SBN 1975 and SBN 1980) have been made stricter regarding heat losses and include a stipulation that the intentional ventilation rate in occupied buildings should be 0.5 air changes per hour (ach). Regulations have also been established which specify a maximum airleakage of 3 ach at 50 Pa pressure difference. This airtightness has been reached by an increased construction cost of between 500 and 2000 Sw Kr per single family house. These rules and the production of more airtight houses has lead to the almost universal use of mechanical ventilation systems, although natural ventilation systems are still permitted. Approximately half of the domestic mechanical ventilation installations are exhaust air systems, some of which incorporate heat pumps for hot water. The remainder are balanced ventilation systems with heat exchangers. The total cost for a mechanical exhaust air system is approximately the same as that for a natural ventilation system; nevertheless, discussions on natural ventilation continue. However, proposed revisions to the Building Code are to include:

- stricter regulations for airtightness (≤ 1.0 ach at 50 Pa pressure difference).
- regulations for heat recovery in new houses which will bring the use of natural ventilation into question.

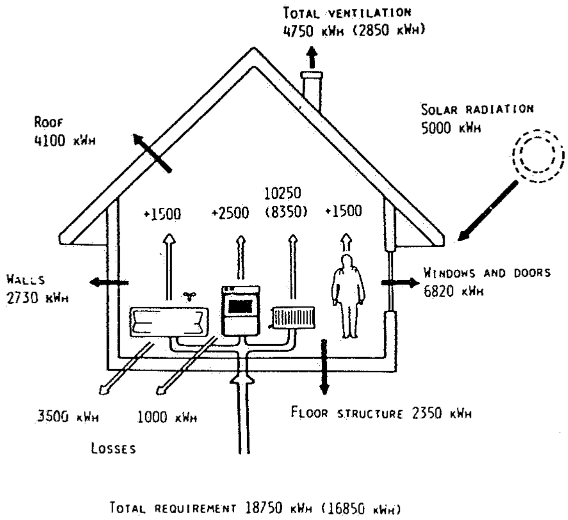

Figure 1. Heat balance at a total ventilation of 0.3 and 0.5 air changes per hour. The values within parentheses correspond to 0.3 ach

Basic knowledge seems to be insufficient in the field of building and ventilation technology. There is no total view of the balance of energy and no regard is paid to the interplay between different flows of energy.

Strongly varying information has been presented concerning airtightness, type of ventilation system, minimum air exchange rate and the technical as well as the economical consideration for heat recovery (Tables 1 and 2). Problems with moisture, mildew and rot are often reported for new houses and have therefore complicated the question.

This paper aims to present facts and ideas to improve cost effective design for airtightness and ventilation systems. Schematically alternative measures to save energy are presented. An investigation for determining the rate of ventilation in some occupied houses is described.

Table 1. Minimum air exchange rate

Depending on	m³/h per person	ach	Notations
Lack of oxygen	0,5		
Problems with CO and CO_2	10–15	0,1–0,2	4 persons, based upon the whole volume
		0.6–1,0	2 persons in a room with 12 m² floor area
Problems with moisture	4	0,2	5 persons in the house. Water vapour: 40 g/person/h and 150 g/h when cooking
Avoid condensation of water on window panes	7		
Unpleasant smell	5–40		Room floor area 41–5 m²
Laundry	?	?	
Cooking (increased ventilation)		0,2–0,6	80–250 m³/h
Unacceptable content of poisonous gases			
–smoking	~20		Depending on room volume
–formaldehyde	?	?	
–radon		~0,3	Timber houses without basement
		~0,7	Timber houses with concrete-basement
		~1,0	Lightweight concrete houses

Measurements for determining the rate of ventilation/heat balance

The mean heat balance for a single family house situated in the south of Sweden is exemplified in Figure 1. Ventilation rate measurements were first made in 25 technically identical, timber framed, single family houses. Two of the houses incorporate balanced ventilation systems with air-to-air heat recovery and the remainder have mechanical exhaust ventilation. These houses were designed in accordance with the Swedish Building Code and have a volume of 320 m³ and a floor area of 155m².

The investigation included:

1. a) Airtightness measurements (pressurization test).

   b) Determination of the relationship between air change rate (tracer gas method) and airtightness at 50 Pa pressure difference.

2. Tracer gas measurements to determine:

   a) The unintentional ventilation

   b) The total ventilation for a mechanical ventilation rate of

      (i) ≈ 0.25 ach (SBN, recommended when houses are unoccupied)

      (ii) ≈ 0.50 ach (SBN, reccommended when houses are occupied)

      (iii) ≈ 1.00 ach (forced ventilation when cooking, etc.)

3. Measurements of airflow through exhaust air terminal devices for alternatives (i), (ii) and (iii). These measurements gave information about the intentional ventilation through the devices and ducts.

Table 2. Increase of production cost and energy conservation for different measures

Measure	Energy conservation kWh/year	Increase of production cost Sw.Kr.
Stricter requirements for airtightness from 3 to 1 changes per hour at 50 Pa	≤ 1000	3000–5000*
Balanced ventilation with heat exchange instead of exhaust air-system	1000–2000	8000
Heat pump using the exhaust air for domestic hot water	1000–2500	5000

*According to some factories only 500 Sw.Kr.

Results

When the mechanical ventilation rate in each of the 25 'identical' houses was set at 0.25 ach (unoccupied condition), the measured total ventilation averaged 0.29 ach (Figures 2 and 3). The minimum value was 0.12 and the maximum 0.50 ach. This difference is approximately equal to 4000 kWh per year in the south of Sweden. The fans in these houses operate with a small total pressure and are therefore sensitive to climatic variations, especially wind fluctuations.

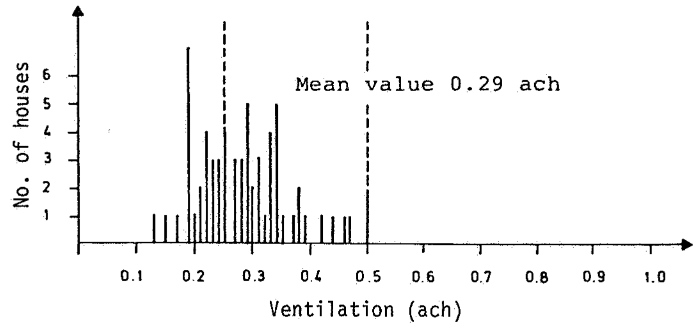

Figure 2A. Measured total ventilation (ach)

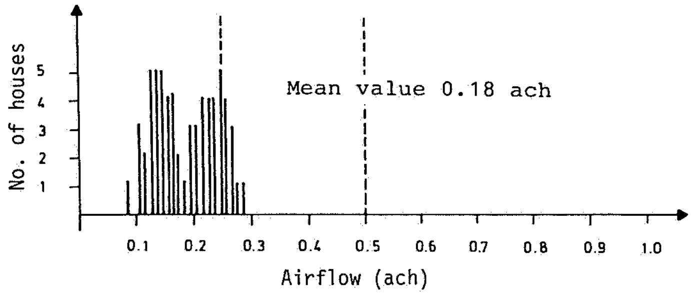

Figure 2B. Measured air-flow through the ventilation system (ach)

Similar measurements made in 5 more-recently constructed houses revealed a mean total ventilation rate of 0.22 ach with actual values ranging between 0.15 and 0.29 ach (Tables 3 to 5). This smaller difference corresponds to 1500 kWh per year in the south of Sweden and was mainly due to ducts with better airtightness and to more successful adjustment of the exhaust air terminal devices.

The measured air leakage at 50 Pa for the 25 'identical' houses varied between 2.6 and 7.4 ach, with a mean value of 4.7 ach. The unintentional natural ventilation averaged 0.14 ach, with measurements ranging between 0.05 and 0.42 ach.

For the five more-recently constructed houses, the corresponding air leakage at 50 Pa varied between 1.7 and 2.1 ach with a mean value of 1.8 ach. The unintentional natural ventilation averaged 0.05 ach with measurements varying between 0.04 and 0.07 ach.

The mean heat balance for the 30 houses is shown in Figure 1.

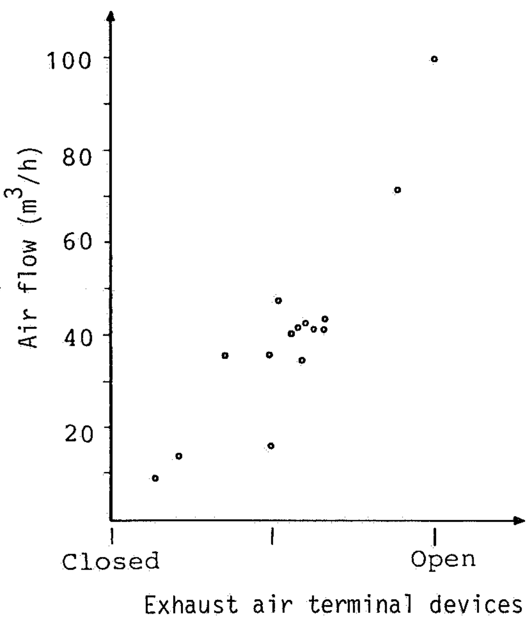

Figure 3. Recorded air-flow and adjustment of exhaust air terminal devices. The devices were presumed to have an air-flow of 50m³/h

Summary of observations

Differences in rate of ventilation between technically 'identical' houses mainly result from defective workmanship, which results in increased air leakage through the ducts, walls, roof and floor. Incorrect adjustment of the exhaust air terminal devices and insufficient job description and operating instructions to contractors and occupants will also contribute to the great differences.

The microclimate will also influence the rate of ventilation but to a lesser extent than the earlier mentioned factors. From the measurements it can be seen that all occupants are satisfied with a ventilation rate of ≈ 0.3 ach. However, a higher ventilation rate is needed when cooking or when several smokers are present in the house.

The indoor climate seems to be satisfactory if the ventilation system is working and there is sufficient air distribution between different rooms of the house.

Planning and production of new buildings, products and installations must be carried out carefully. Good design, appropriate building materials, suitable production conditions, conducive working environment and a satisfactory quality control are of great importance.

Airtightness and type of ventilation system

As previously mentioned, stricter regulations for airtightness are being discussed in Sweden. Such a decision must, however, be based upon technical and economic realities. The interplay between microclimate, unintentional and intentional ventilation, and type of ventilation system must be considered. Measurements and calculations made by Larm[6,9] (see also Figure 4), show that the total ventilation will be approximately 0.1 ach lower if the airtightness is 1 ach instead of 3 ach at 50 Pa. Our own investigation has given this result too.

Table 3. Airtightness at 50 Pa

House No.	Air leakage at 50 Pa			
	Positive pressure difference (m^3/h)	Negative pressure difference (m^3/h)	Mean value (m^3/h)	Mean value (ach)
2	894	830	862	2.1
4	772	685	729	1.8
6	758	710	734	1.8
8	704	713	709	1.7
10	768	753	761	1.8

Table 4. Measured airchanges per hour (ach)

House No.	Unintentional ventilation 2a	Basic rate ~0,25 ach 2b(i)	Basic rate ~0,50 ach 2b(ii)	Forced ventilation 2b(iii)	Temperature °C Indoors	Temperature °C Outdoors
2	0.06	0.29	0.55	0.81	21.4	12.4
4	0.07	0.24	0.44*	0.90	17.4	10.0
6	0.04	0.15	0.43	0.92	19.5	12.3
8	0.05	0.21	0.52	1.08	19.0	16.4
10	0.04	0.24	0.51	0.89	20.8	7.4
					Wind velocity 0–2 m/s	

*The slot valves were closed during the measurement.

Table 5. Measured total ventilation (tracer gas method) and air flows through the exhaust air terminal devices (m^3/h)

House No.	Unintentional ventilation	Basic rate ~0,25 ach		Basic rate ~0,50 ach		Forced ventilation	
		Total ventilation	Through the exhaust air terminal devices	Total ventilation	Through the exhaust air terminal devices	Total ventilation	Through the exhaust air terminal devices
2	25	120	67	227	185	335	301
4	29	99	74	182*	184	372	319
6	17	62	60	178	171	380	312
8	21	87	60	215	181	447	348
10	17	99	78	211	185	368	313

*The slot valves have been closed during the measurement.

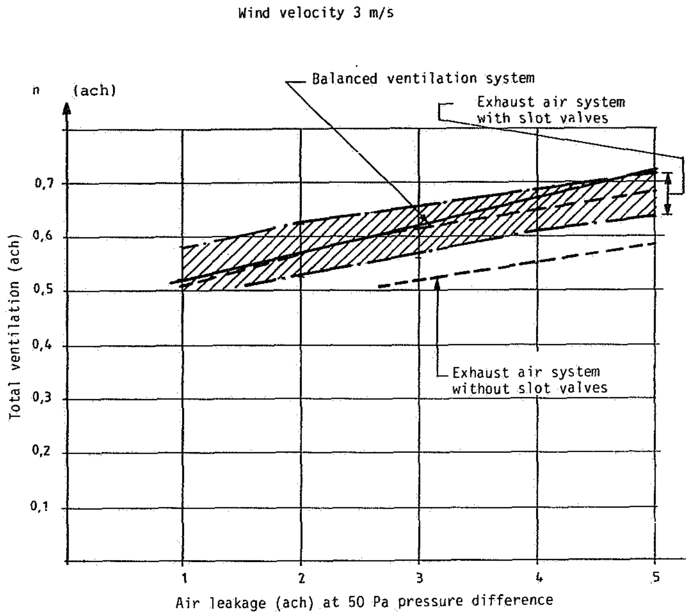

Figure 4. Total ventilation at different airtightnesses for balanced ventilation system and exhaust air system with or without slots

To achieve an airtightness of less than 1 ach at 50 Pa pressure difference, joints should, as a rule, incorporate sealants and adhesive tapes, possibly in combination with plastic sheeting. Sometimes, faults resulting in increased air leakage have been discovered after a few years. The durability and ageing properties have not been considered sufficiently. Movements in foundations and wood-based materials have also resulted in an increased air leakage.

The relationship between the rate of air flow and pressure difference is somewhat different for the building, its ventilation system (including devices and fans) and the supply air devices (slots) (Figure 5). For example, the capacity of the fan in an exhaust air system is sometimes so low that it is not capable of obtaining 0.5 ach if the occupants close the supply air slots. The positioning of ducts, devices and slots can result in a ventilation rate which is too low for the whole house or for individual rooms, in a vertical as well as horizontal direction.

The economical and technical arguments for a higher quality of airtightness than that corresponding to 3 ach at 50 Pa pressure difference are doubtful. However, a house with

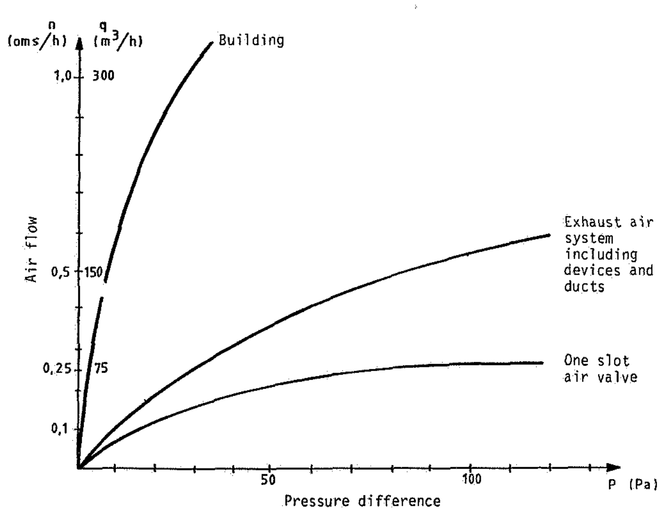

Figure 5. The relationship between air flow and pressure difference for the building, one slot, exhaust devices and ducts

greater airtightness will result in a more effective mechanical ventilation system. Different airtightness rates will perhaps be necessary, depending on the type of ventilation system. Balanced ventilation systems with heat exchangers will probably require an airtightness of no more than 1 ach at 50 Pa pressure difference.

From experience, mechanical exhaust air systems seem to be the most efficient type of ventilation system, from a total point of view. Natural ventilation systems seem to be dangerous in airtight houses. A combined ventilation and warm air heating system might be interesting but requires further research work.

Modified exhaust air systems

By adding an exhaust air terminal device in every room the cost will rise by about 500 Sw.Kr. Through this change of design the exhaust air system will be improved and the influence of slot air valves will be mainly eliminated. It will also be possible to save energy through a 'demand adjustment' of the ventilation system in different rooms and on different occasions. The ventilation efficiency will increase and the air change rate can probably be reduced for the whole house, Lögdberg[12].

Alternatively the exhaust air system can be complemented with a heat-pump for hot water. This seems to be an interesting technical and economical measure. Owing to the large possibilities of saving energy with this type of heat-pump, the design ought to also include space heating. This could be realized by a large radiator or water tube circuit around the external walls.

A new design for supply of fresh air through thin plastic tubes has been tested. This will make it possible to exclude slot air valves in windows and walls.

Conclusions

Research and development work concerning airtightness and ventilation should include projects which, in a few years, will be able to answer the following questions:

1. Different building materials, foundation and type of houses have varying ventilation requirements. Is it possible to reduce the air change rate from 0.5 to 0.3 ach in
   - prefabricated timber houses?
   - with or without basements?
   - houses built with light weight concrete?
2. How much energy can be saved by quality control, and by providing better job descriptions and operating instructions to contractors and occupants?
3. From technical and economic points of view, which measures are appropriate for higher airtightness and different types of ventilation systems? For example, modified exhaust air systems,
   - incorporation provision for space heating?
   - with exhaust air terminal devices in every room?
4. How much energy can be saved through a 'demand adjustment' of the ventilation system in such a way that good ventilation is obtained in those rooms where people spend longer periods?

Different measures and combinations of measures to save energy ought to be introduced in order to obtain the lowest total costs.

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All in Swedish except 11 and 12.

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12. Arne Lögdberg: The impact of ventilation and airtightness on energy consumption. Energy efficient domestic ventilation systems for achieving acceptable indoor air quality. Supplement to proceedings. 3rd AIC Conference, Berkshire, October 1982.

Reminder

The Handbook 'Air infiltration control in housing – a guide to international practice' announced and described in the previous edition of AIR is available direct from:

Svensk Byggtjänst,
Box 7853,
S-103 99 Stockholm,
Sweden.

Price: Skr 95

The Assessment of the Interaction of Airborne Contamination with Building Ventilation Performance

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Introduction

Various stages in the manufacture of goods in rubber or other polymers give rise to airborne contamination in the factory workroom. Investigations have been carried out over the last three years in industrial buildings housing a variety of manufacturing processes. These investigations were to collect data prior to the designing of solutions to improve the control of airborne contamination. A study of the data reveals that the satisfactory control of airborne contamination in a workroom depends on many factors. It is necessary to take into account all relevant factors so that a satisfactory solution can be achieved. This paper outlines the type of data that is collected, how it is collected and interpreted and what conclusions can be drawn.

Data Collection

Contaminant Source and Behaviour

Air sampling, using normal occupational hygiene techniques, reveals where personal exposure to airborne contamination is above permitted levels. This leads to the need to review where the contamination is coming from, how it is produced and how it behaves once it is emitted into the workroom atmosphere.

The physico-chemical properties of the contaminant and action of the process can usually be determined by the engineer with the co-operation of the works chemist. However, the engineer also needs to know about the behaviour of the contaminant, local to the process and when it is entrained in the workroom atmosphere.

Behaviour local to the process can be studied using a dust lamp[1], Schlieren photography[2], or Infra-red techniques[3,4] as appropriate. The rate of release of contamination can be estimated from the shape and size of the emission combined with velocity of the contaminant.

An estimate of volume flow rate is required where this is generated by stack effect due to heat from the product or process causing emission of contamination. It may be relevant to measure temperature of the air current generated by stack effect and of the product or process. Both contact and remote sensing of temperatures are useful.

Behaviour of contamination when entrained in the workroom atmosphere is best assessed using arrays of static samplers or portable air sampling equipment with a direct read-out.

Exhaust Ventilation

Exhaust ventilation, both general and local, has its performance measured using conventional methods[5] such as Pitot-static tube traverses of ducted systems. Volume flow rates are thus obtained for all exhaust systems in a workroom.

Supply Air

A similar exercise is carried out to measure the volume flow rates of all supply air to the workroom.

Passive sources, such as louvres or vents are measured where possible, in addition to mechanically powered supply air systems.

Workroom Pressure Differentials

Pressure differences between the interior of a workroom and atmosphere or adjacent rooms, may exist as a result of wind pressure, stack effect or imbalance of exhaust over supply air. Measurements are made of these pressure differentials at convenient places around the workroom when all the workroom ventilating equipment is working normally. A sensitive manometer, reading to 1 Pa is required[6]. Mean wind velocity and direction at the time of the test are noted.

Air Currents in the Workroom

Air currents can be created by one or more of the following means: movement of people, transport or machinery; wind pressure; stack effect; building leakage; mechanically-supplied air; imbalances of exhaust and supply air. Smoke is used to visualise air currents and a velometer is used to estimate gross volume flow rates.

Discharges from Exhaust Ventilation Systems

It is important to assess the performance of the discharge arrangements and the behaviour of the contaminated air when it is discharged from an exhaust system to the atmosphere. Besides a physical check of the geometry of the discharge arrangements, the efflux velocity of the contaminated air is measured.

The behaviour of the contaminated air can often be assessed by direct viewing or taking 'dust lamp' photographs using the sun.

Staining of the surroundings of a discharge also reveals useful information as to the behaviour of the contaminated air. Smoke can be injected into the exhaust air so as to make air patterns visible.

Wind data are obtained from the nearest meteorological office. This is then turned into a wind rose which is drawn onto a site plan so that an assessment of the effect of prevailing wind can be made.

Typical Data

Once on-site data have been collected, calculations can be made, the results collated and conclusions drawn. Alterations to the equipment or the process can then be designed.

The results of some actual investigations are summarised in Table 1. This Table illustrates typical values that are obtained from studies of workroom ventilation performance.

Table 1. Some typical data

Item	Units	Factory			
		1	2	3	4
Product		Tyres	PU foam	Hose	Wheels
Airborne contamination type (see note 1)		RPF	TDI	RPF	Spray paint
Does process generating contamination occupy whole or part of workroom?		Part	Whole	Part	Part
Floor area of whole workroom	m^2	20290	1370	1890	8309
Volume of whole workroom	m^3	146090	8200	11800	50480
Floor area of workroom containing process	m^2	5072	1370	995	502
Volume of workroom containing process	m^3	36553	8200	5900	3050
Total exhaust from workroom	m^3/s	145	22	15	34
Total supply air to workroom	m^3/s	36	13	0	0
Pressure difference relative to atmosphere (note 2)	Pa	–20	–4	–5	–0.5
Pressure difference relative to adjacent workroom	Pa	–13	–2	–	–5
Exhaust efflux velocity (average) (note 3)	m/s	–	12	8	–
Exhaust discharge direction (note 3)		down	up	horizontal	down
Is exhaust discharge above or below highest point on building?		below	above	below	below
Is there contaminant entrainment from other parts of workroom?		no	yes	no	yes
Is there contaminant entrainment from adjacent workroom?		no	no	no	no
Is there re-entrainment from discharges?		yes	no	yes	yes

Notes:

1. RPF = rubber processing fumes. TDI = toluene diisocyanate.
2. Largest value.
3. Exhaust discharges via some designs of weather cowl deflect downwards and do not allow efflux velocity to be measured.

Interpretation of Data

Workroom Air Balance

Airflow in and out of a given volume of workroom must be in balance. This balance can be summarised as:

Σ mechanically powered exhaust air + Σ ex-filtration

= Σ mechanically powered supply air + Σ infiltration.

From measurements made on mechanically-powered supply and exhaust systems, and on volume flow rates through such workroom openings as vents, louvres and doorways, we can draw up an air balance. The degree of out of balance of mechanically-exhausted air with respect to mechanically-supplied air will be reflected in the measurements of pressure differential between the workroom and atmosphere or adjacent workrooms. Airflow will then result from these pressure differentials.

When contaminated air has escaped into a workroom atmosphere, it will be entrained in the workroom air currents. This contaminated air can then eventually pass the breathing zone of a person in the workroom. This mechanism is often the reason for higher than expected exposures to airborne contamination when a person works at an exhaust-ventilated work station.

Movement of contaminated air from one part of a workroom to another, or from one workroom to a neighbouring workroom, can be a source of background contamination in an otherwise unexpected location.

Re-entrainment of Contamination from Discharge

The combination of wind, stack height and location, efflux velocity, building shape, surrounding topography and climatic conditions[7] can militate against satisfactory dispersal of contaminated air from an exhaust system discharge stack.

As a minimum requirement, exhaust systems must discharge vertically[8], above the highest point[8] on the building and at an adequate efflux velocity[7]. If this is not done, there will be a downwash from the stack which will be entrained in air currents generated by the interaction of wind with the building[7,8].

With contaminated air being held close to the building, it can then re-enter the building either via supply air inlets or via building infiltration. The end result is the same as that discussed under workroom air balance. Contaminated air passes the breathing zone of people in the workroom.

Conclusions

It is necessary to make comprehensive measurements and observations of the behaviour of airborne contamination and how it interacts with building ventilation performance. Engineering designs for airborne contamination control to improve standards of occupational hygiene, can only be made on the basis of taking all the relevant factors into account.

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   Air Conditioning, Heating and Ventilating, November 1959, p60–62.

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   Loughborough University of Technology.

8. Industrial ventilation: A manual of recommended practice: 15th Edition, p6–19 to 6–20 and 6–39 to 6–41.

Recent Acquisitions

The following papers have recently been acquired by the Air Infiltration Centre's library:

1. Ward, I.C., Sharples, S.
   An investigation of the infiltration characteristics of windows and doors in a tall building using pressurization techniques.
   Dept of Building Science Report BS68, University of Sheffield, August 1982.

   Sets out the design and construction of pressure test rigs for use in windows and doorways.

*2. Penman, J.M., Rashid, A.A.M.
   Experimental determination of air flow in a naturally ventilated room using metabolic carbon dioxide.
   Building and Environment, Vol. 17, No. 4, 1982, p253–256.

   Reports extension of the metabolic CO_2 method to a naturally ventilated room.

3. Sandberg, M., Blomqvist, C., Sjöberg, M.
   Warm air systems:
   Part 1. Temperatures and temperature efficiencies.
   Part 2. Tracer gas measurement and ventilation efficiencies.
   Swedish Building Research Institute, Bulletins M82:22 and M82:23, 1982.

   Reports results from more than 100 tests of 6 different warm air schemes.

Copies of the paper marked with an asterisk are available from the AIC to organisations in participating countries. The remainder are available on loan.

Development of a Multi-Tracer Gas Technique for Observing Air Movement in Buildings

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Introduction

A method for following air movement within buildings, which uses several different tracer gases simultaneously, has been developed. The method consists of the following sequence of operations:

- up to four tracer gases are released at various points within the building.
- the mixture of gases is sampled at any number of positions in the building as a function of time since the release.
- the samples are chemically analysed to produce curves showing the concentrations of each gas stepping through time and space.
- the variations in gas concentrations are used to evaluate air movement through the space. Specific experiments to illustrate such air movement have been carried out and these are summarised below.

Tracer Gases and their Release

An extensive survey was carried out to find non-toxic, odourless tracers with a zero background concentration. It was also necessary to find unreactive chemicals whose concentrations were easily measured, and which could be readily separated for analysis. A series of perfluoro hexanes and decalins fit the requirements and the following ones have been used in the prototype development:

- PP1 perfluoro n-hexane
- PP2 perfluoro methyl cyclohexane
- PP3 perfluoro dimethyl cyclohexane
- PP5 perfluoro decalin

These compounds are low boiling liquids which makes for easy transport. They are currently injected into a space (remotely or manually) by evaporating about 1 ml using an electric heater. In some cases the gas is mixed with a desk fan.

Sampling and Analysis

Mixtures of room air and one or more tracers are sampled by drawing a small fixed volume of air (about 100 mls) through sample tubes packed with an adsorbent. Figure 1 illustrates the system for two sample points. Each sample point (Plate 2) consists of five removable stainless steel tubes packed with an adsorbent (chromosorb 102). At the front end of each tube a push cap fitting connects it to a solenoid valve which controls the exposure of the tube to the atmosphere. The pump, flow meter, pressure gauge, needle valve, three port solenoid valve and T piece are housed on a small trolley (Plate 1). Also included is the control system which opens and closes the solenoid valves. The valves are operated so that the tubes are exposed in pairs, one at each sample point. Samples are thus taken simultaneously at each point and in a timed sequence from 1 to 5. The sample tubes are capped for transportation to the automatic thermal desorber (Plate 3) where up to 50 tubes may be desorbed.

The tracer gases are desorbed from the sample tubes using a Perkin-Elmer Sigma 3B gas chromatograph fitted with a 4 m glass column packed with 5% SE30 on CHROM W.H.P. and a flame ionization detector (Plate 4).

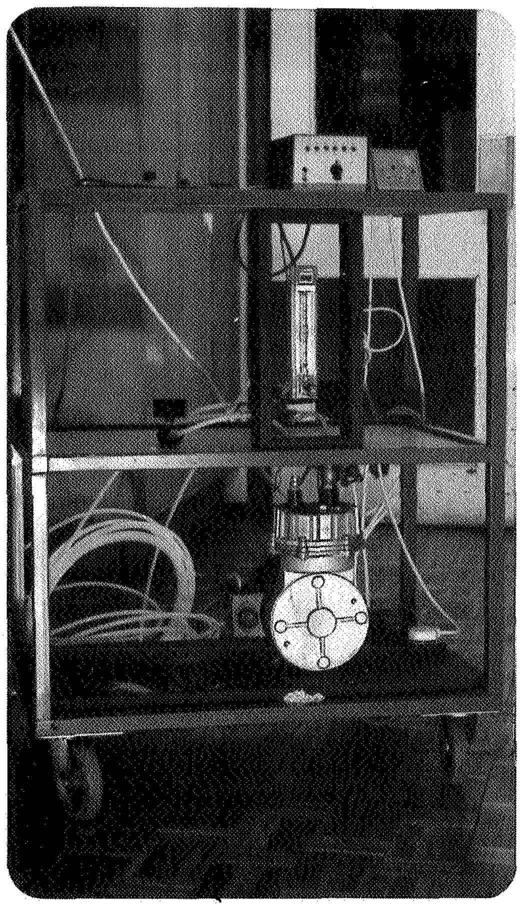

Plate 1. Pump and controller

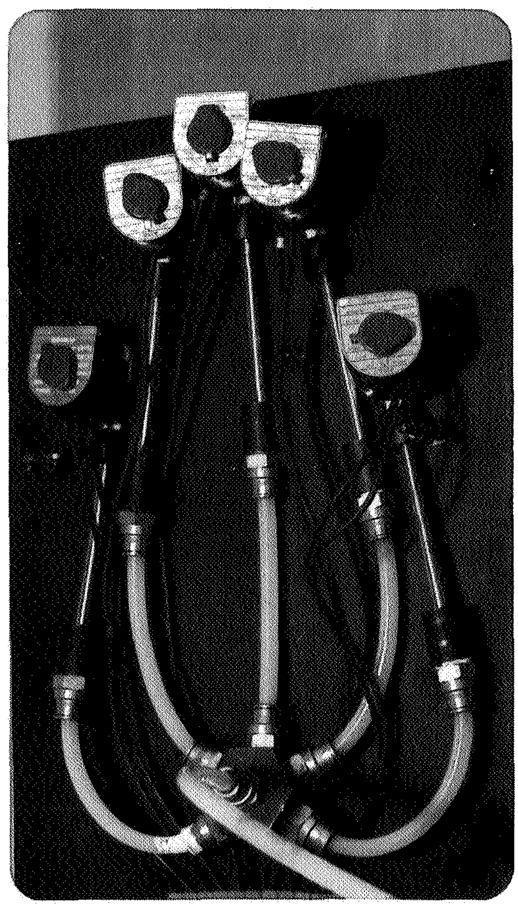

Plate 2. One sample point

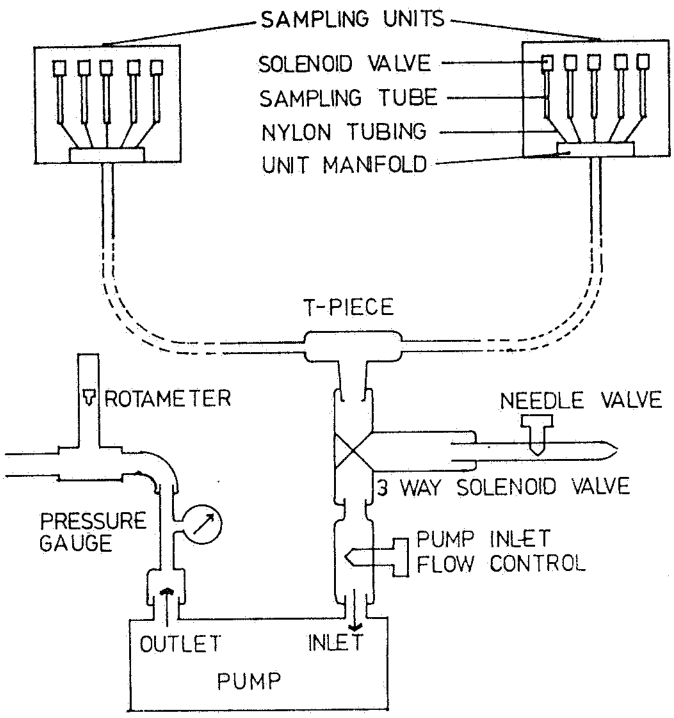

Figure 1. The sampling system

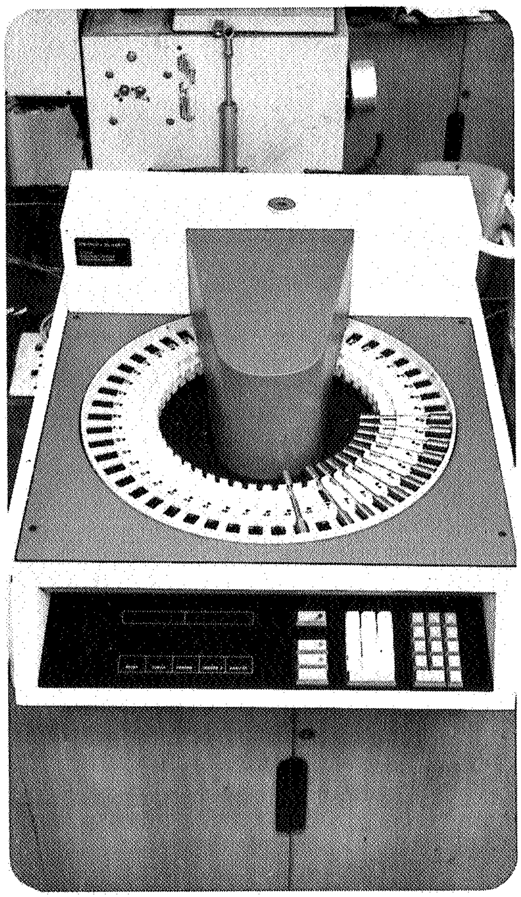

Plate 3. Automatic thermal desorber

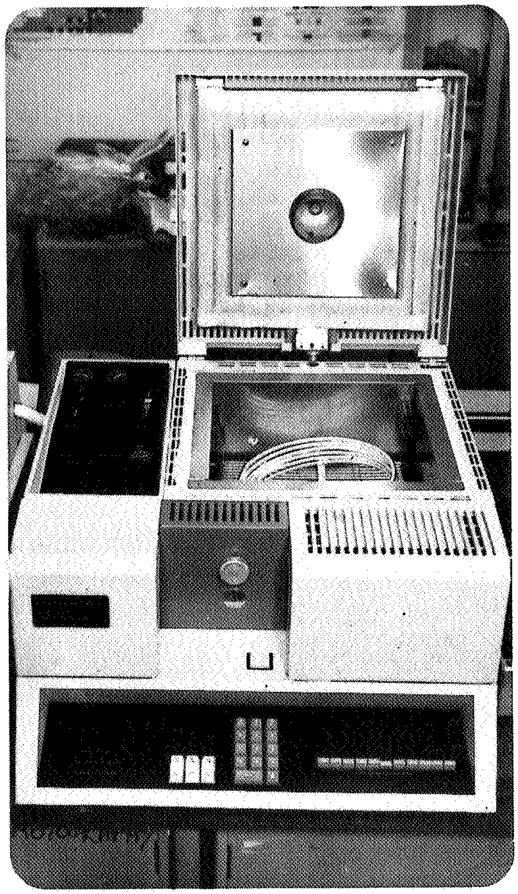

Plate 4. Gas chromatograph

Demonstration of the Technique

Tests for Absorption into Walls and Furnishings

Method

An office of volume 33 m³ with a false panelled wall, carpeted concrete floor, concrete ceiling and large sliding double glazed windows was sealed with tape over joints in the wall, gaps in the ceiling, the window frame and the skirting board.

The tracer release system was set up in the middle of the room with an oscillating fan to ensure good mixing. 1 ml of each tracer was evaporated in the room and the door sealed from the outside with the fan switched on. After 27 minutes the fan was switched off. After another 3 minutes the first sample was taken. A further four samples were taken at intervals of 30 minutes. The test was repeated using intervals of one hour (Figure 2) and intervals of one minute between samples.

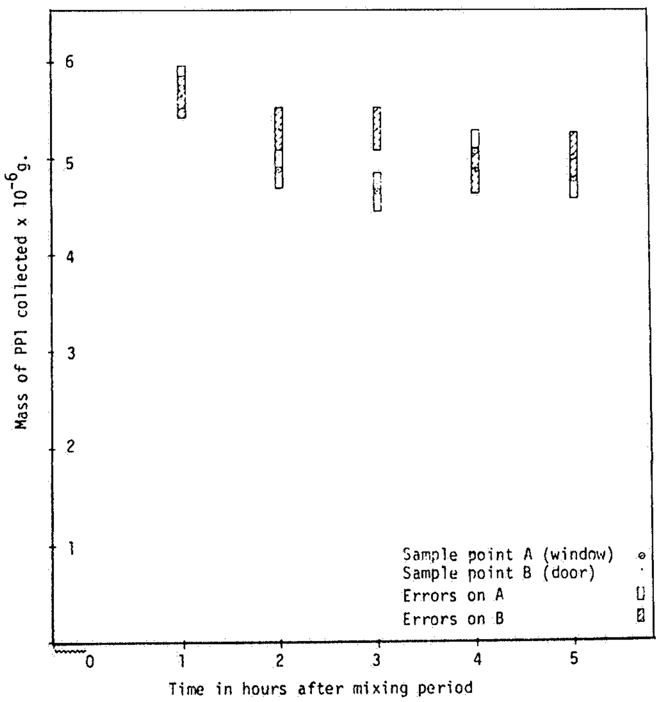

Figure 2. Room surface absorption test with PP1

Results

Figure 2 illustrates the variation in concentration of one tracer (PP1) up to 5 hours after its release into the sealed room. Between hours 1 and 5 the mean concentration in the room air at the two sampling points falls from 5.7×10^{-5}g/l to 5.0×10^{-5}g/l. The small drift downwards is probably due to residual infiltration occuring in the room, even though it was carefully sealed. A log linear plot of the data in Figure 2 implies a rate of only 1.7×10^{-2} air changes per hour.

Similar tests were carried out with the other tracer gases and the air change rate obtained by averaging all the results for this five hourly period was $(1.7 \pm 0.3) \times 10^{-2}h^{-1}$.

The conclusion is that the gases are not adsorbed by walls and furnishings.

Tests for Stratification

Method

Sampling point A was 2.89 m above the floor, and point B 1.36 m. The ceiling to floor height was 2.95 m. 30 minutes after the tracers were released, sampling commenced at 30 minute intervals. In one test a desk fan was left on to mix the room air, and in a second test the fan was not used.

Results showed that no significant stratification occured in a 2½ hour period.

Experiment To Show Air Movement Between Two Zones Using Two Tracer Gases

Two sampling points were set up, one in the sealed room used in the previous tests and one in the corridor outside the room.

Two tracers were released, one in each zone. Air in each zone was mixed, with the communicating door closed. Samples were taken before opening the door, and at 5 minute intervals after it was opened. Figure 3 shows some of the results. PP1 (full line) is released in the sealed room, and after mixing reaches a concentration of 4.60×10^{-5}g/l (roughly 4 ppm). Its concentration in the corridor is very small (less than 0.2×10^{-5}g/l). PP3 is released in the corridor and after mixing reaches a concentration of 2.35×10^{-5}g/l. Its concentration in the room is zero.

When the door is opened, PP1 is swept into the corridor – leading to a fall in room PP1 and a rise in corridor PP1. Similarly, PP3 is swept into the room, with a concomitant fall in the PP3 concentration in the corridor.

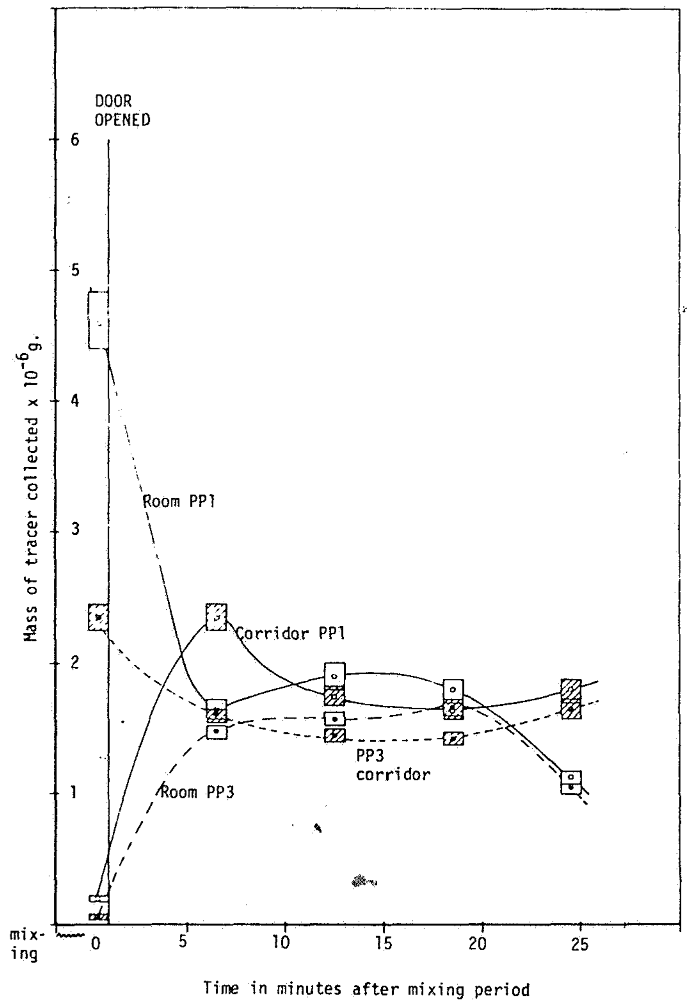

Figure 3. Typical curves for a two-zone, two-tracer test

Forthcoming Conferences

1. Second International Congress on Building Energy Management
   Ames, Iowa, USA
   May 31 – June 3 1983

   Further information from:

   Office of the Secretariat
   c/o Prof. James E. Wood
   Iowa State University
   102 Scheman Building
   Ames
   Iowa 50011
   USA

2. ASHRAE Semi-Annual Meeting
   Washington DC, USA
   June 26 – 30 1983

   Will include a symposium entitled 'Air infiltration model validation'

   Further information from:

   R.S. Burkowsky
   ASHRAE
   1791 Tullie Circle N.E.
   Atlanta
   GA 30329
   USA

3. PLEA '83
   International Conference on Passive and Low Energy Architecture
   Crete, Greece
   June 28 – July 5 1983

   Will include case studies on retrofits and research and development in ventilation, modelling and simulation

   Further information from:

   PLEA '83
   Architectural Association Graduate School
   36 Bedford Square
   London, WC1B 3ES
   Great Britain

1983 Survey of Current Research

The Air Infiltration Centre is in the process of updating its world-wide 'Survey of current research into air infiltration in buildings' which is being extended to include ventilation-related aspects of indoor air quality.

Two years ago the previous survey attracted 149 replies but since then a substantial number of new projects have been initiated and our aim is to make this review more extensive and as comprehensive as possible. To this end, we are seeking your co-operation. If you are currently involved in air infiltration or related air quality research, please complete the attached form and return it to the Air Infiltration Centre as soon as possible.

The project details provided on the questionnaire forms will be published in a single volume together with an analysis of the main subject areas and experimental techniques so that the document will provide a ready reference to the many research programmes and their principal researchers. While the analysed results of this survey will only be available to organisations in participating countries, contributors from other countries will receive a complete listing of survey replies.

Make sure your project is included by returning the completed form no later than 30 June 1983. Guidelines for completing the survey form are given below.

Instructions for describing research projects

The following information should be included in the description of the project:

Specific objectives

Include the primary aims of the project and its relationship (if any) with previous or other current studies.

Project details

(a) Measurements in buildings

- (i) type of building, e.g. house, apartment, commercial, factory, office, etc.
- (ii) size and construction type, e.g. brick, wood, concrete, etc.
- (iii) natural or mechanical ventilation system and type of heating system (gas, oil, etc.).
- (iv) measurements being taken, e.g. pressurization, type of tracer gas, surface pressures, pollutant type, etc.
- (v) brief instrumentation details.
- (vi) occupied or unoccupied building.

(b) Theoretical/model calculations:

Please indicate conceptual approach, estimation technique and validation trials.

Parameters with which infiltration and indoor air quality will be related

Please include the following where appropriate:

(a) weather (temperature, wind, humidity, etc.)

(b) performance of building components (windows, doors, etc.)

(c) behaviour of occupants (real or simulated).

(d) sources of pollution.

(e) other.

Forthcoming Conferences

4. CIB '83 – 9th CIB Congress
Stockholm, Sweden
August 15 – 19 1983

Further details from:

The National Swedish Institute for Building Research
PO Box 785
S-801 29 Gävle
Sweden

5. **4th AIC Conference**
'Air infiltration reduction in existing buildings'
Elm, Switzerland
September 26 – 28 1983

For further information please contact your Steering Group Representative (see back of this newsletter)

6. Third International Symposium on Building Economics
Ottawa, Canada
July 18 – 20 1984

Subject areas include

- *New concepts for assessing and measuring economic performance of buildings.*
- *Economic optimization of building design*
- *Computer-aided cost modelling*

Further information from:

Mr A.A. Wilson
Division of Building Research
National Research Council
Ottawa
K1A 0R6
Canada

7. The 3rd International Conference on Indoor Air Quality and Climate
Stockholm, Sweden
August 20th – 24th 1984

Further information from:

Conference Secretariat
Indoor Air '84
c/o Resco Congress Service
S 105 24 Stockholm
Sweden.

Survey Form

Current Research into Air Infiltration and Related Air Quality Problems in Buildings

For office use only	
££T #REF	Title of project ______
££N CONTACT	Principal researcher ______
££T ££N ADDRESS	Organisation ______
	Address ______
	Telephone ______ Telex ______
#infodate	Date survey form completed ______ <
££N DESCRIP	**Description of Project**
	Specific objectives ______
££P <	Project details ______
££P <	Parameters with which infiltration and indoor air quality will be related ______ <
#startdate	Date project began ______
#endate	Expected termination date ______
#time	Estimated number of man hours ______
££N KEYWORDS	______
££N BIBLIOG	Important reports and publications, both past and future, (titles, authors, publishers, dates of publication)
££A	*Please return completed form to:*
	The Air Infiltration Centre, Old Bracknell Lane, Bracknell, Berkshire, RG12 4AH, Great Britain.

3rd fold (insert in Flap A)

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Old Bracknell Lane West
Bracknell
Berkshire
RG12 4AH
Great Britain

2nd fold (Flap A)

1st fold

AIC Publications List

PERIODICALS

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

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

TECHNICAL NOTES

AIC-TN-1-80 **Manning, S.**
'The distribution of air leakage in a dwelling — a brief review', 4pps.
Contains a review of 15 papers describing measurements of the distribution of air leakage in a dwelling. The results of leakage measurements made in 81 buildings are summarized.
Available free-of-charge to participating countries only.*

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

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

AIC-TN-4-81 **Manning, S.**
'Instrumentation for the measurement of air infiltration — an annotated bibliography', 16pps.
An annotated bibliography containing 89 references to papers selected from the AIC's library and intended to be selective rather than comprehensive. Includes references only to papers entirely or substantially concerned with instrumentation or containing information about a particular measurement technique. References are divided into three sections according to subject: tracer gas methods, pressure tests, and other associated techniques such as thermography and acoustic detection of leakage paths.
Available free-of-charge to participating countries only.*

AIC-TN-5-81 **Allen, C.**
'AIRGLOSS: Air Infiltration Glossary (English Edition), 124 pps.
Contains approximately 750 terms and their definitions. They are related to air infiltration, its description, detection, measurement, modelling and prevention as well as to the environment and relevant physical processes. Translations of the glossary from English into languages of participating countries will appear in due course.
*Available free-of-charge to participating countries.** *Price: £10 to non-participating countries.*

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

AIC-TN-7-81 **Liddament, M.**
'1981 Survey of current research into air infiltration in buildings', 222pps.
Second worldwide survey by AIC, containing 149 replies from 20 countries. Produced in three sections: an analysis in tabular form of survey results, reproduction in full of research summaries, and details of projects completed since previous 1980 survey. Includes appendix of names and addresses of principal researchers.
Available free-of-charge to participating countries only.*

AIC-TN-8-82 **Thompson, C.**
'A subject analysis of the AIC's bibliographic database — *AIRBASE.*' 2nd Edition, 84pps.
Comprehensive register of published information on air infiltration and associated subjects. The 875 articles are indexed by subject and full bibliographic details of the papers are given. A list of principal authors is also included.
Available free-of-charge to participating countries only.*

AIC-TN-9-82 **Liddament, M., Thompson, C.**
'Mathematical models of air infiltration — a brief review and bibliography'.
Contains a brief description of 14 mathematical models of air infiltration with bibliography of relevant papers. The theory behind mathematical modelling is outlined and the advantages and disadvantages of the various types of models are described. Comments are given on the range of applicability of the models reviewed.
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 (16 references).
No. 2 Pressurization — Infiltration Correlation: 2. Measurements (24 references).
No. 3 Weatherstripping windows and doors (18 references).
No. 4 Caulks and sealants (18 references).
No. 5 Domestic air-to-air heat exchangers (22 references).
No. 6 Air infiltration in industrial buildings (8 references).
No. 7 Air flow through building entrances (15 references).
No. 8 Air infiltration in commercial buildings (23 references).
No. 9 Air infiltration in public buildings (10 references).

CONFERENCE PROCEEDINGS

No. 1 'Instrumentation and measuring techniques'.
1st AIC Conference, 6–8 October, Windsor, Berkshire, UK, 372 pps, £35.00 sterling.

No. 2 'Building design for minimum air infiltration'.
2nd AIC Conference, 21–23 September 1981, Stockholm, Sweden, 216 pps, £15.00 sterling.

No. 3 'Energy efficient domestic ventilation systems for achieving acceptable indoor air quality'.
3rd AIC Conference, 20–23 September 1982, London, UK, 432 pps, £17.00 sterling.
Supplement to 3rd AIC Conference Proceedings (contains five additional papers, 1 amended paper, discussion), 160 pps, £6.50 sterling.

***The participating countries are: Canada, Denmark, Italy, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom and the United States of America.**

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