Air Infiltration Review
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Beginnings of Air Infiltration Studies in New Zealand

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The winter climate in New Zealand is temperate, windy, with reasonable sunshine. Early efforts in conservation of building heating energy concentrated on items with the most predictable immediate return, namely thermal insulation and more effective use of windows. Only after these measures had been securely introduced did attention turn seriously to other conservation measures.

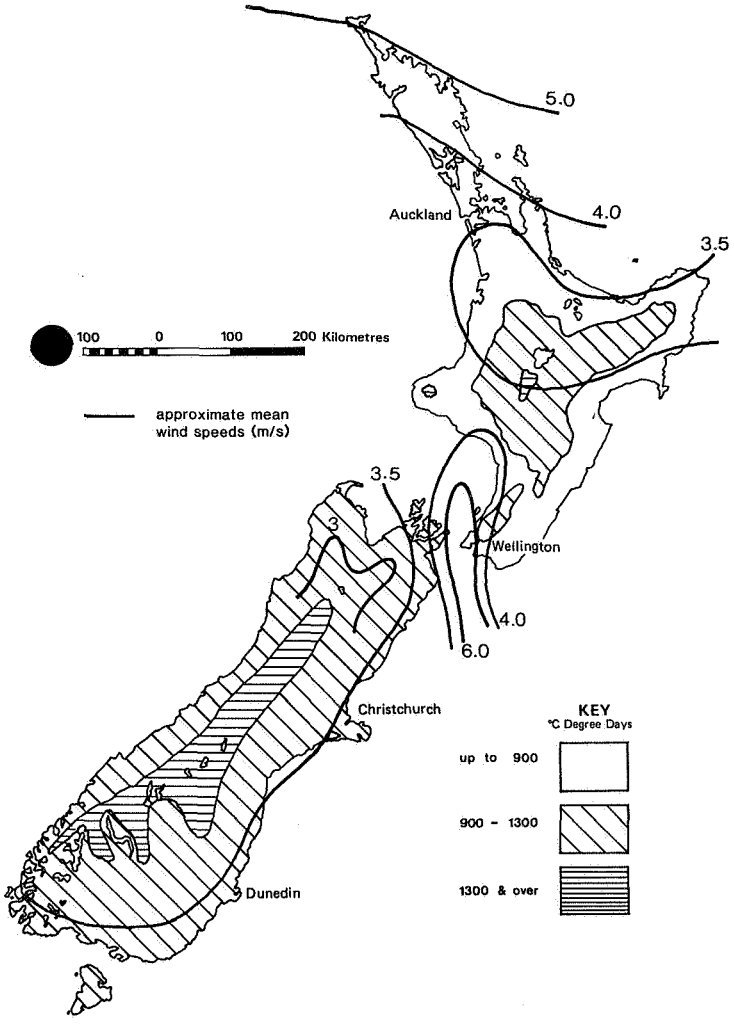


Figure 1. Map showing climatic zones and approximate mean wind speeds in New Zealand.

When this happened, it soon became apparent that air leakage and ventilation was the next important issue. But that discovery was made at a time of economic recession, and resources to pursue the subject were not immediately available. Air leakage is now taken to be a major factor, not only in its direct effect on ventilation heat losses, but also on its dominant influence in structural moisture control, and hence on both the dynamic state heat losses and on material durability.

Research on air leakage has recently been started by the Building Research Association and other groups are being encouraged to become active. Current areas of activity include:

- airtightness tests of houses
- ventilation rate measurements
- material air leakage resistance measurements
- structural cavity air exchange measurements.

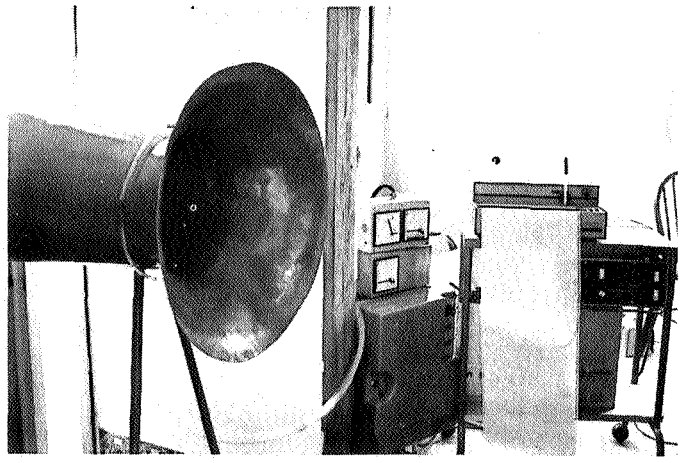


Figure 2. Flow metering nozzle and pressure recorder in operation during an air tightness test.

Air Tightness and Air Infiltration Rates in Houses

Portable equipment for measuring house air tightness has been constructed (Figure 2). It consists of a 380 mm aerofoil fan mounted in an adjustable door panel and powered by a lightweight 1600 W three phase motor. Synchronous speed control is achieved with a device synthesising variable frequency three phase power from any 230 V single phase outlet. A preliminary survey of 20 houses gave leakage rates over a wide range of 7

to 20 air changes/hour at 50 Pa. The tighter houses of the group were mostly newer houses constructed with sheet lining materials and aluminium window joinery. Those at the loose end were older with timber joinery. The survey is being extended to cover more houses and some in considerable detail to build up a picture of where the major leakage openings are located.

A series of natural air change rate measurements have been performed by T.S. Clarkson of the New Zealand Meteorological Service. They employed the tracer gas decay method using SF_6 as the tracer material. Simultaneous wind speed and direction measurements were made on site and an approximately linear fit between air change rate and wind speed obtained. Results for two houses are shown in Figure 3 which encouragingly suggest that in the absence of large indoor/outdoor temperature differences, a workable model of air leakage in terms of wind speed and air tightness may be obtainable.

The next objective will be to test various air leakage models against this and additional experimental data obtained in our moderately leaky houses located in a windy climate. On this basis, the role of air leakage in controlling condensation, wasting space heat and providing fresh air will be assessed.

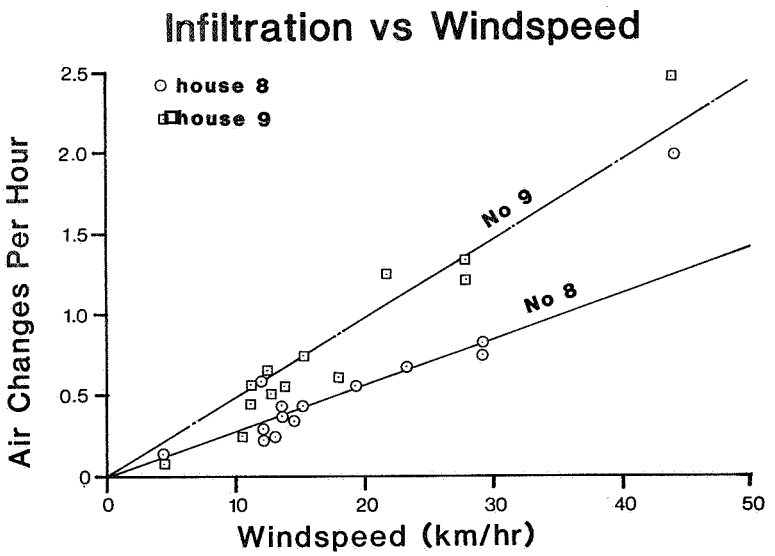


Figure 3. Air infiltration rates measured at a variety of different wind speeds and directions. The two houses concerned were newly constructed and not finished internally. They are of timber frame construction of similar size. House 9 has timber window joinery and house 8 aluminium joinery.

Dampness Related Problems

Dampness related problems fall into two classes; those occurring within the living space and those where moisture accumulates within the structure. Both are considered to depend on air leakage to a large extent.

A survey of the incidence of dampness in New Zealand houses (BRANZ report CR2) concluded that:

> 'The incidence of mildew growth and surface dampness in New Zealand housing is very high (45%). The most common problem reported is mildew in wardrobes (25%) followed by mildew on bedroom walls (20%), mildew on other walls (11%), visible dampness on bedroom walls (9–10%). In about 20% of all homes dampness problems are serious.'

Figure 4 is an example of serious mildew on a bedroom wall. Problems of this nature are so frequently encountered that the Building Research Association has prepared leaflets advising

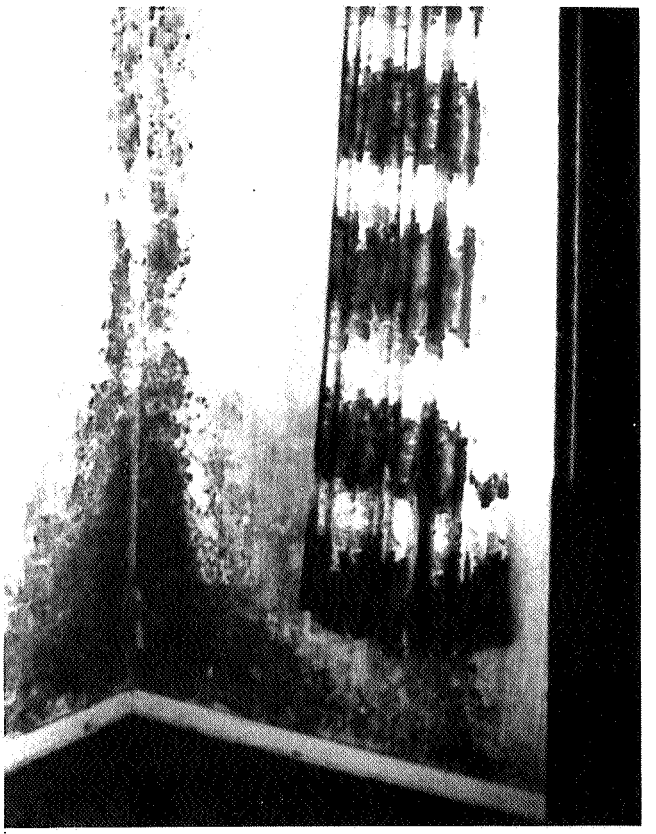
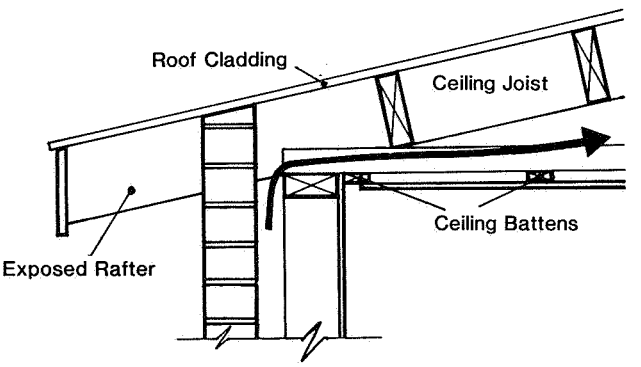


Figure 4. Mildew growth on a bedroom wall.



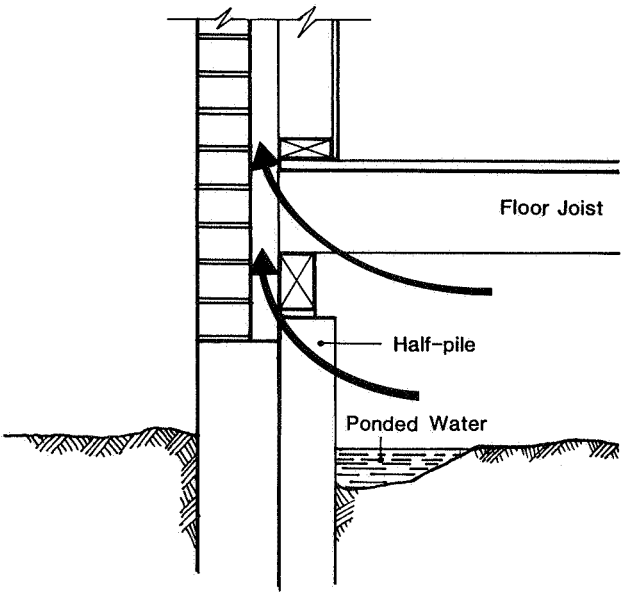


Figure 5. Air leakage path leading to cavity condensation.

home owners about remedial measures. Mostly these centre around an adequate standard of heating and ventilation with suggestions of how this should be timed with the major moisture releasing activities. Extract fans or vents are frequently located in kitchen and bathroom areas but ducted air distribution systems with or without heat recovery are not found in New Zealand houses.

A Prevalent Wet Roof Space Problem

An increased number of wet roof space problems has posed interesting questions about the mechanisms of moisture transfer within structures and the susceptibility of new insulated houses constructed without vapour barriers.

Various mechanisms for the accumulation and eventual dispersal of moisture in the roof space have been considered and the first to be eliminated on grounds of being insufficient was vapour diffusion through ceiling linings. A series of site inspections has shown a strong correlation with a combined damp subfloor space and an open wall cavity. This leads to the hypothesis that the moisture has been carried by air movement from the damp subfloor, up the wall cavity to the roof where it has condensed on the cold cladding exposed to the night sky. This hypothesis is currently being tested with tracer gas studies of subfloor to roof space air movement and by selectively fixing a number of cases by blocking the wall cavities.

This example has been discussed here because it illustrates the importance of air driven moisture transfer and its frequent dominance over vapour diffusion in the problems we see.

Air Leakage Resistance of Materials

In the absence of vapour barriers, the major resistance to air leakage is a combination of the diffusion resistance of wall ceiling and floor lining materials and the openings at joints. A survey of the air flow resistance of sheet lining materials has shown that leakage through the bulk material will form an insignificant part of room air change rates. While the resistance to air flow through some lining materials in the unfinished state fall in the range 0.55—1.0 MNs/m^3 the application of paint and wall papers generally increases this resistance by several orders of magnitude.

Future Activity

Energy conservation research in New Zelaand for the next few years will be emphasising:

- air leakage and infiltration
- the effects of air leakage on moisture control and space heat loss
- the interchange of air and airborne water vapour between structural cavities.

3rd AIC Conference

'Energy efficient domestic ventilation systems for achieving acceptable indoor air quality'

20th – 23rd September 1982 at Park Court Hotel, London, UK

With the introduction of low-leakage building design and the upgrading of the thermal performance and airtightness of existing buildings, it is becoming increasingly important to design and install purpose provided ventilation systems. These are necessary to ensure good indoor air quality and air distribution whilst at the same time minimising energy consumption due to ventilation losses.

The International Conference will provide a forum for researchers, designers and housing managers to discuss progress in the design and application of energy efficient domestic ventilation systems. The scope of the conference includes developments in the areas of both controlled natural and mechanical ventilation systems. Particular interest will be focussed on practical experience of the effective use of alternative systems. A total of 27 papers will be presented by authors from 8 countries.

The Park Court Hotel provides first class accommodation and conference facilities. It is pleasantly situated overlooking Kensington Gardens near Hyde Park, easily accessible by public transport and close to the West End – famous for its shops and entertainment.

Registration Fee

Delegate fee per person – £200.00 inclusive of VAT. To be received no later than 23rd August 1982. Booking will only be accepted on receipt of registration fee.

The registration fee includes overnight accommodation on nights of 20th – 22nd September, 1982 – inclusive English breakfast, lunch and dinner within conference period – full conference facilities – printed papers.

Further details and booking forms are available from your Steering Group representative.

Seminar on air leakage at ASHRAE Semi-Annual Meeting in Toronto, Canada 27th June - 1st July 1982

Reported by David Harrje, Princeton University, USA.

Two seminars were held at the recent ASHRAE meeting on air leakage in buildings. The first was entitled 'Air tightness measurements in residential buildings' and the second 'Air leakage in large buildings'.

Five contributions were presented in the first seminar, beginning with a presentation by R. Grot and A. Persily from the US National Bureau of Standards and was a review of fan pressurization techniques. The need to take account of wind effects while conducting these tests was stressed. A seasonal variation in air leakage was also noted.

The second contribution to this session was by G. Proskiw from UNIES Ltd, Winnipeg, Canada. He reported on the results of air leakage tests made on new airtight houses. Leakages as low as 0.1 ach at 50 Pa were measured. The main source of variation in leakage between dwellings was found to be contractor quality control. It was stated that air change rates below 0.3 ach at 50 Pa should be possible by careful construction.

The next presentation by R. Dumont from National Research Council, Saskatchewan, Canada, was on airtightness measurements on residences sealed to reduce air leakage. Robert Dumont reported that the pressure test has emerged as a popular tool in Canada. A wide range of 'before' and 'after' measurements were reported, to illustrate the effectiveness of retrofits.

The fourth contribution was by M. Sherman of the Lawrence Berkeley Laboratory, California, USA. Entitled 'An accurate method for measuring real time leakage', this described the 'AC' pressurization/depressurization technique which enables air leakage to be studied under low flow conditions. Recent measurements showed that the flow component tends to unity as the building becomes tighter. Also the flow exponent varies throughout the pressure range, from unity at low pressure differences to 0.5 at high pressure differences.

The final paper of the first seminar described a novel transient pressure pulse technique for airtightness measurements in houses and was presented by G.K. Yuill of UNIES Ltd. The method involved the rapid release of gas under pressure into a building. The build-up in pressure differences and the subsequent decay was measured. Tests have not yet been performed in dwellings.

There were four contributions to the second seminar. The first, by Mr McGugan of the Ontario Research Foundation, Mississauga, Ontario, Canada, described whole building pressurization measurements and pressure tests across individual components.

This was followed by a presentation entitled 'Air leakage in Federal office buildings — an overview of the effects and means of detection and quantification' by R. Davidge of Public Works Canada, Ottawa, Ontario, Canada. It described the use of infra-red aerial surveys coupled with 'over' pressurization using the building's HVAC plant to force warm air through leaks.

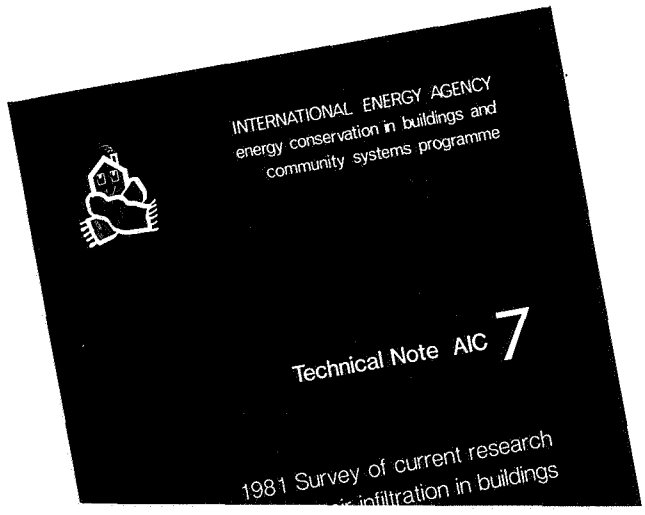
The third contribution concerned building for airtightness and was presented by J. Perreault of the Construction Company, Edmonton, Alberta, Canada. He illustrated the problems associated with interpreting building design. It was pointed out that a building which looked good on paper need not necessarily be airtight when constructed.

The final presentation was entitled 'Designing for airtightness' and was given by K. Burn of National Research Council, Canada. He stressed the need for a continuous vapour barrier with proper consideration being given to junctions. A particular problem is associated with building joints where temperature variations and moisture cause movement which may result in air leakage.

ASHRAE seminars provide a forum for details of current research to be discussed informally and, therefore, the proceedings of these sessions are not published. However, the Air Infiltration Centre will provide further details of these developments as they become available.

AIC Survey of Current Research into Air Infiltration in Buildings

To facilitate regular updating of the Air Infiltration Centre's survey of current research, all research summaries are stored on a computer database which may be readily accessed using the Centre's free text retrieval system. Staff at the AIC will be pleased to search this database for any up-to-date information you may require on current research.



Copies of AIC Technical Note 7 describing the results of the 1981 survey are still available to organisations in participating countries and may be obtained by contacting the Air Infiltration Centre directly, or by using the attached Publications Order Form.

Let Others Know .....

Air Infiltration Review offers the opportunity for brief, informative articles relating to air infiltration research and its application. Contributions of general interest on, for example, new projects, developments in instrumentation, novel applications of energy saving, natural or mechanical ventilation systems, or behavioural effects on infiltration would be most welcome.

Why not prepare an item for the next issue? Last date for receipt of copy is 4th October 1982.

Forthcoming Conferences

1. CIB/CIE Environmental Workshop.
The Effects of Interpersonal Differences on Design Criteria.
Chester, Great Britain.
September 15th – 17th, 1982.

Further information from:

Mrs J. Hughes
Electricity Council Research Centre
Capenhurst
Chester
CH1 6ES
Great Britain

2. 3rd AIC Conference.
Energy efficient domestic ventilation systems for achieving acceptable indoor air quality.
Park Court Hotel, London, UK.
20th – 23rd September 1982.

For further details, see page 3

3. CIB Symposium on Building Climatology.
Moscow, USSR.
September 20th – 24th, 1982.

Further details from:

Prof. V.A. Prozdov
Director NIISF
Gosstroy USSR
Marx Avenue 12
Moscow k-9
USSR

4. ASHRAE/DOE Conference.
Thermal Performance of the Exterior Envelopes of Buildings II.
Las Vegas, Navada, USA.
December 5th – 9th, 1982.

5. ASHRAE Semi-Annual Meeting.
Resorts International, Atlantic City, New Jersey, USA.
January 23rd – 27th, 1983.

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

Further information from:

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

7. 9th CIB Congress.
Stockholm, Sweden.
August 15th – 19th, 1983.

This congress will focus on problems connected with shortage of resources and to the care and use of existing building stock.

Further details from:

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

Recent Acquisitions

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

*1. D'Silva, N.S.
Operating experience with a residential mechanical ventilation system with heat recovery.
Ontario Hydro Research Division, Report No. 81-51-k, March 1981, 25pp.

Assesses the efficiency of an engineered mechanical ventilation system in controlling indoor humidity in one of the HUDAC Mark XI houses.

*2. Jones, W.R., Stricker, S.
Ventilation requirements and natural air leakage in residences.
Ontario Gydro Research Review, No. 4, December 1981, p17–21.

Discusses problems of air quality in tight buildings and describes techniques for measuring air leakage and typical results.

3. Swedish Council for Building Research.
Right combination of measures in the right building at the right time – energy conservation in the form of combinations of measures.
Swedish Council for Building Research Report D10:1981, 52pp.

Describes a new method (minisystem analysis) developed for the calculation of the energy conservation potential of a building.

Copies can be ordered from :

Swedish Council for Building Research
Sankt Göransgatan 66
S-112 30 Stockholm
Sweden

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

New Publications from the Air Infiltration Centre

Literature Lists

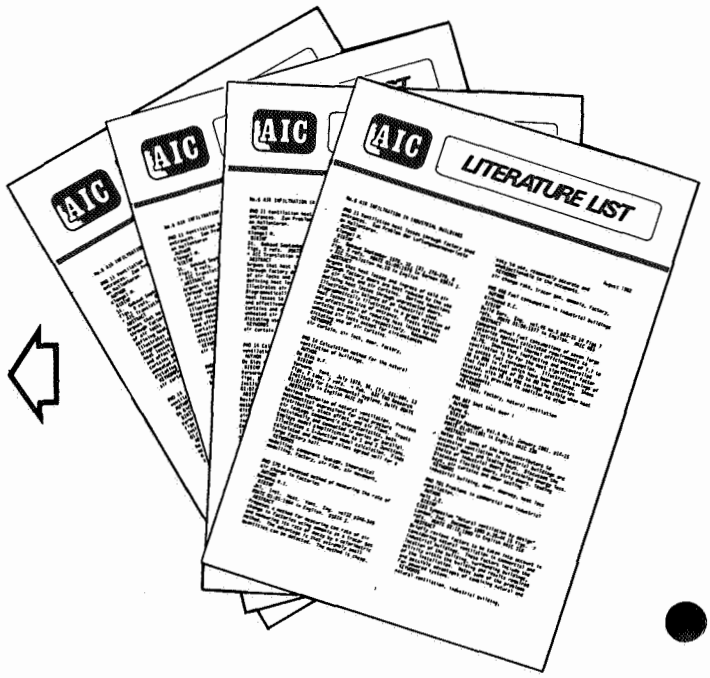
To date the AIC has produced seven literature lists on particular topics related to air infiltration. To provide additional information, these lists have now been updated and restructured to include the abstract as well as the title and reference of relevant papers.

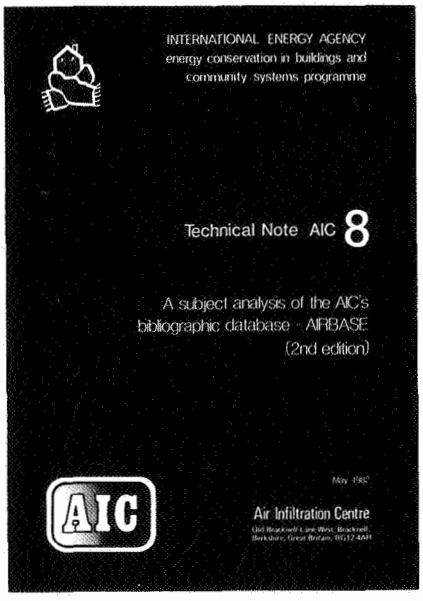
Topics covered are:

- Pressurization – infiltration correlation: 1. models
- Pressurization – infiltration correlation: 2. measurements
- Weatherstripping windows and doors
- Caulks and sealants
- Domestic air-to-air heat exchangers
- Air infiltration in industrial buildings
- Air flow through building entrances

These literature lists are the results of *AIRBASE* searches on topics of common interest. They provide a handy reference to published information on selected subjects.

Organisations in participating countries may obtain copies by applying to the AIC Library using the attached AIC Publications Order Form.





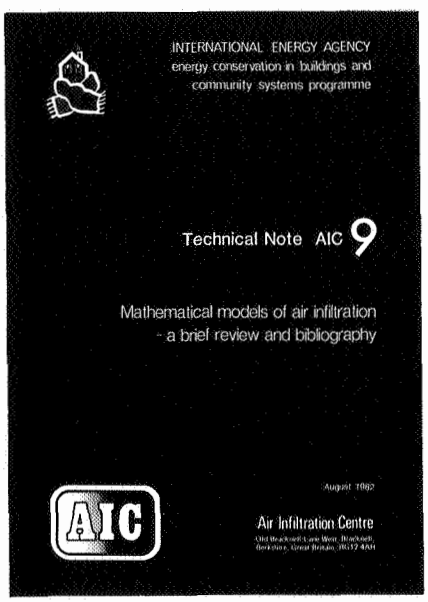
AIC-TN-8-82 A subject analysis of the AIC's bibliographic database – *AIRBASE*

Since the first subject analysis of *AIRBASE* was produced in 1981, the database has grown from 621 to 875 abstracts, at the rate of 20 articles per month. This technical note gives an updated subject analysis of *AIRBASE* with its increased content. The report is divided into two parts: Section 1 consists of 13 tables each with a major subject heading and sub-headings under which the reference number order, of all 875 papers. The report can thus be used as a subject index by looking up a reference number under a relevant heading in Section 1 and turning to Section 2 for full bibliographic details of the paper. In addition, an index of principal authors of papers listed in *AIRBASE* is appended to the report.

The publication is thus a comprehensive register of published information on air infiltration and associated subjects and will be a valuable reference document for all those concerned with this field of knowledge and application.

AIC Technical Note 9
Mathematical models of air infiltration – a brief review and bibliography

This technical note contains a brief analysis and bibliography of mathematical modelling techniques used in the estimation of air infiltration in buildings. The theory behind air infiltration modelling is described and general details of 14 models are given. These range in complexity from 'single cell' approaches, in which the interior of the building is assumed to be at a single uniform pressure, to 'multi-cell' methods, in which the interior is partitioned into areas of differing pressures interconnected by flow paths. The various applications of these models and details of the key parameters that must be defined in order to obtain reliable estimates of air infiltration are described. The bibliography contains abstracts of papers from *AIRBASE* referred to in the review.



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.
No. 2	Pressurization – Infiltration Correlation: 2. Measurements.
No. 3	Weatherstripping windows and doors
No. 4	Caulks and sealants.
No. 5	Domestic air-to-air heat exchangers.
No. 6	Air infiltration in industrial buildings.
No. 7	Air flow through building entrances.

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.

**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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