Air Infiltration Review

a quarterly newsletter from the IEA Air Infiltration Centre

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The Team at your Service

Dr Carolyn Allen joined the staff of the Air Infiltration Centre on 17 July 1980. She graduated in Geology and Astronomy at the University of Leicester in 1970, then proceeded to the University of Newcastle-upon-Tyne where she obtained her MSc in Geophysics and Planetary Physics as part of which she studied convection in fluids with variable viscosity. Subsequently she read for her Ph.D. in the Atmospheric Physics Research Group being largely concerned with the physics of splashing drops. This was followed by a period as a research assistant with the same establishment working on a mathematical model for boundary layer flow over complex terrain.

Carolyn Allen is to be involved in the systematic organisation of a data base suitable for the validation of mathematical models and the formulation of standardised procedures for reporting test results.

Carolyn Allen
Scientist

With the arrival of Carolyn Allen, the AIC staff is now up to full strength. The other members are:

Peter Jackman
Head—AIC

Martin Liddament
Senior Scientist

Sheila Manning
Librarian

Jenny Elmer
Secretarial Assistant

Now that the AIC has been established, the bibliographic data base inaugurated and the team of experts engaged, we are progressing rapidly in our studies on the technical aspects of air infiltration with particular emphasis on mathematical modelling procedures and the collection of reliable test data. Enquiries from research organisations in participating countries indicate that we are becoming recognised as a centre of valuable information and expertise.

Seminar on Air Quality

A seminar entitled 'Health in the Home' was held at the Electricity Council's Research Centre at Capenhurst in May and attended by the AIC's librarian, Sheila Manning. Seven papers were presented on the subject of the quality of air in dwellings.

Of particular interest was a paper presented by B.L. Davies of the National Radiological Protection Board on the problem of radon gas in the home. The paper included estimates of the lung cancer risks from radon and found inter alia that a mean winter ventilation rate of 0.5 air changes per hour would give a lung cancer risk equivalent to smoking 2.2 cigarettes per wk.

AIR INFILTRATION IN SWITZERLAND

As part of their international liaison work, two of the AIC staff, Peter Jackman and Martin Liddament, spent a week during May in Switzerland. The visit was at the kind invitation of Peter Hartmann, the Swiss representative on the AIC Steering Group. In addition to providing a very interesting tour of his own laboratories at the Section of Building Physics of the Swiss Federal Laboratories for Materials Testing, EMPA, in Duebendorf, Peter Hartmann organised visits to other establishments involved in various aspects of air infiltration.

He also described the current situation in Switzerland with regard to air infiltration as follows:

'Ventilation and Infiltration in Swiss Buildings

Dwellings are generally naturally ventilated, with mechanical ventilation and heat recovery systems being seldom used. In newer homes infiltration is mainly confined to windows and doors whilst in older properties infiltration is often enhanced by shafts up through the building. Exhaust fans are used for internal toilets and bathrooms and sometimes, in addition to windows, in kitchens. Mechanical ventilation is more common in industrial and office buildings and air conditioning plants are used in some instances. Schools tend to be naturally ventilated.

Energy Consumption

Heating accounts for about 50% of the total energy consumption of Switzerland. Approximately a third of this energy demand is needed to satisfy heat losses due to air infiltration. As insulation standards improve, the air infiltration component of heat loss will become more significant.

Building Codes and Standards

Only recommendations are made on a national basis, these are then acted on by Cantons. For residential buildings there are no standards on overall air tightness or on air change rates or fresh air quantities per person per hour. There are, however, standards governing the maximum level of leakiness of windows.

Research

The Building Physics Section of EMPA is currently making detailed measurements of air infiltration and energy consumption of a typical detached dwelling in Maugwil (see photograph). Automatic monitoring equipment was installed during the construction of the house last year. Two methods of measuring infiltration are being used: automatic tracer gas decay and pressurization—the effect of occupants opening windows is part of the study and measured by the following two methods:

1. Based on a statistical survey conducted in West Germany window opening schedules were fixed. Three levels of energy consciousness of occupants were included.

2. Windows were partially opened and the infiltration rates measured for the individual rooms.

The results of this work will be published this year.

Other projects at EMPA include the determination of the influence of window tightness on air infiltration and energy consumption and a study of the relationship between parameters and window opening behaviour. Various laboratory tests on the different characteristics of windows are also being conducted.

Research into the health aspects associated with minimum ventilation requirements is being studied by Dr H. Wanner of the Institute for Hygiene (ETHZ) and Work Physiology at the Technical University, Zurich (ETHZ). His work includes studying the effect on air quality of odours and of pollutants emitted by building materials.

Research into heat losses due to , among other things, air infiltration is being examined by Mr G. Gottschalk from the Institute of Applied Physics, EPRL, Lausanne.

Research Needs

There is a need to develop methods to correlate pressure test measurements with air change rates for typical atmospheric conditions. It is also necessary to gain a detailed knowledge of window opening behaviour and to assess the influence of window opening on energy consumption. Finally, both technical and educational means should be used to achieve the full energy saving potential of reducing air infiltration. Care must be taken, however, to ensure that minimum ventilation requirements are satisfied.'

Dr Wanner and his assistant, Mr G. Huber, discussed their work in greater depth when Peter Jackman and Martin Liddament visited the Institute for Hygiene and Work Physiology. They demonstrated their techniques for the subjective assessment of the strength of odours by comparison with a standard sample. Mr Huber will be presenting a paper on this work at the AIC Conference in October.

The test house at Maugwil was the subject of a visit later in the week. Also attending this visit were Mr de Coulon and Mr Luginbühl from the Swiss Federal Office of Energy. This office is partly funding the test house project.

Visits were made to two factories; Schmidlin in Aesch and Egokiefer in Alstatten. Schmidlin specialises in producing purpose-designed windows and facades for commercial buildings. Egokiefer produce wooden, aluminium-faced and PVC window frames for domestic and other applications. After observing the production areas of both these factories, the various testing facilities were demonstrated. These tests included air infiltration, rain penetration, acoustic performance and heat loss. The importance of minimising the heat loss through the window frame as well as the glazing was stressed. The surface area of the window frame could amount to 20% of the total window area. Mr Spörric of Egokiefer said that he thought PVC frames were the window frames of the future. They are widely used in Germany and demand for them is increasing elsewhere. The relative costs of wooden, plastic and aluminium-faced window frames are in the ratio of 1:1.2:1.5 respectively.

Other visits were to:

- a recent air-conditioned office development.
- a low energy house incorporating passive solar heating.
- an apartment block under construction.

The wide range of visits and discussions that took place during the course of the week served to illustrate the methods being used by the Swiss to control air infiltration and thereby reduce energy demand in the office and home.

Introducing AIRBASE

The AIC's bibliographic database, named AIRBASE, is now established at Bracknell.

AIRBASE contains information in English, abstracted from papers written in more than twelve different languages, covering all aspects of air infiltration. The database is continually updated by AIC staff as new material is acquired by the library.

Members of institutions in participating countries who wish to make use of AIRBASE are asked to contact the AIC with details of their requests. In addition to providing abstracts of articles on particular subjects, we are able to supply photocopies of original papers—subject to the usual copyright practice.

An informative guide to the use of AIRBASE is currently being prepared and will be circulated to participants as soon as possible. This guide will enable users to formulate their requests in a way which will ensure than an effective search for relevant material is conducted.

AIRBASE is at your service.

Recent Acquisitions

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

1. Dumont, R.S. et al.
   'Measured energy consumption of a group of low-energy houses.'
   To be presented at 1980 Annual Conference, Solar Energy Society of Canada. Vancouver 6–19 August.

   Presents quantitative measurements on the space heating and total energy consumption of a group of low-energy passive solar houses.

2. Dickson, D.J.
   'Ventilation with open windows.'
   Electricity Council Research Centre M1329, April 1980, 49p.

   Discusses ventilation patterns, air flow at open windows, energy cost of ventilation, room ventilation rates and ventilation rates with windows open or closed.

3. Ekstrand, J.E. et al.
   'Ventilation i smahus'.
   (Ventilation in small houses)
   Byggmastaren No. 5 1980 p17–20.

   Discusses ventilation rates in small houses and the requirements of the Swedish Building Code. Discusses a newly-built 1½ storey house as an example (in Swedish).

4. Elmroth, A., Logdberg, A.
   'Well insulated airtight buildings, energy consumption, indoor climate, ventilation and air infiltration.'
   Presented at 8th CIB Congress, Oslo, June 1980, 19p.

   Reports study of indoor climate and energy consumption in a number of new houses. Includes results of pressure tests made over a period of three years.

5. Nusgens, P., Guillaume, M.
   'Ventilation naturelle des maison individuelles.'
   (Natural ventilation in single family houses)
   C.S.T.C. Revue No. 1, March 1980, p4–16.

   Reports results of three programmes of measurement of ventilation rates carried out in one-family houses. Includes pressure tests of joints and windows (in French).

6. Penman, J.
   'An experimental determination of ventilation rate in occupied rooms using atmospheric carbon dioxide concentration.'
   Build. & Environ. Vol. 15, No. 1, 1980, p.45–47.

   Describes tests in Exeter University Library of a method of determining ventilation rate by measuring the concentration of atmospheric carbon dioxide.

7. 'Construction details of air tightness.'
   Records of the DBR Seminar/Workshop. Proceedings No. 3, Division of Building Research, National Research Council of Canada, April 1980.

   Contains five papers discussing details of construction and design.

8. 'Health in the home.'
   Proceedings of a CIBS/RSH Seminar, Capenhurst, May 1980.

   Contains seven papers discussing all aspects of indoor air quality.

ASHRAE Symposium on Calculating Infiltration

At the recent ASHRAE Meeting in Denver, nearly 100 people attended a symposium entitled 'Calculating infiltration: an examination of the Models'. Four papers were presented which reviewed the wide range of models which exist for predicting infiltration.

The simplest models considered were those currently described in the ASHRAE handbook, i.e. the air change model, and the crack model. It was shown that if used carefully, these models could give an estimate of infiltration which is adequate for plant sizing, but not precise enough for consideration of indoor air quality.

The second model was based on a correlation between pressurization tests and infiltration developed at LBL. By means of a few simple expressions defined by the characteristics of the house and climate, the user is able to define whether the infiltration is wind or stack dominated, and then estimate the infiltration. An essential element of the model is a site measurement of leakage.

The other two papers described computer type models. Both are based on mass balance solutions of the governing equations. The two models, although both requiring computer solution, exhibit a considerable difference in complexity. The first is a single cell model, assuming uniform permeability in a given wall. The second was a multicell network model based on a full definition of all the cracks, plus an allowance for background leakage and turbulent flow reversals.

There was general agreement that there was a need for the validation of the various models against quality data sets. The role of AIC in fulfilling this need was stressed.

Forthcoming Conferences

1. Clima-2000 7th International Congress of Heating and Air Conditioning. Budapest 17–19 September 1980.

   Information from:

   Committee of Organisation,
   Epitoipari Tudomanyos,
   Egyesulet,
   Budapest,
   Hungary.

2. International Conference on Energy Resources and Conservation Related to Built Environment. Miami Beach, Florida. December 7–12 1980.

   Information from:

   Dr Oktay Ural,
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   Miami,
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   U.S.A.

3. The UK Chartered Institution of Building Services (CIBS) will be holding two one-day seminars later this year:

   'Insulated buildings and their services', 23 September, Vickers Building, Millbank, London.

   'Natural ventilation by design', 2 December, Building Research Establishment, Garston, Herts.

Build Tight – Ventilate Right

This article has been submitted by Dr Arne Elmroth, Professor at the Royal Institute of Technology, Stockholm. It reflects the Swedish approach to the problem of energy losses and discomfort arising from air infiltration in dwellings.

The energy crises of 1973–1974 was a stark reminder of the need for energy-saving measures. The Swedish Building Regulations of 1975 increased the requirements for thermal insulation considerably. A significant news item was the introduction of completely new requirements and recommendations for a building's airtightness. The main aim of the new airtightness requirements was of course to save energy. Excess natural and uncontrolled ventilation of air leakage means that the heat required for ventilation increases for a number of reasons. Excess ventilation air must be heated to room temperature. A comparatively small reduction in unneccesary ventilation results in considerable energy savings.

Leaks can also cause local draughts which must be compensated by higher room temperatures to maintain comfort levels. If uncontrolled draughts are reduced, the circumstances for reducing the indoor temperature improve while still maintaining comfort levels—this in turn leads to beneficial energy savings. Air leakage can cause localised cooling of inside sections of external wall constructions causing a sensation of radiation draughts. Damage resulting from moisture penetration through gaps in the building shell have occurred all too often causing considerable damage. The risk of moisture damage is considered to be greater in houses with balanced ventilation than in houses with exhaust air ventilation. Even a small amount of internal positive pressure can cause moist air to leak through pervious structures causing, at worst, condensation and subsequent moisture damage. This problem has also been observed in Canada since it has a climate similar to Sweden. Apart from energy considerations, there is a number of hygienic and technical reasons for making a house's shell 'airtight'.

In Sweden, experience of how airtight houses should be built and how they function is now being gained. It appears that contractors have adapted comparitively quickly to building houses in which the requirements in the building regulations are fulfilled.

Different materials and building procedures demand different approaches. When using solid elements of lightweight concrete, leakage problems are confined to joints around windows and doors as well as at junctions between roofs and outside walls. In timber houses, the vapour barrier is commonly used to achieve airtightness. To produce good airtightness, the constructional details must be planned with greater care than has been the case to date. New age-resistant plastic films have been developed. Several different sized sheets are available to facilitate rational sealing work. However, it still remains to find simpler and safer methods for many different constructional details in order to further facilitate the work of building airtight houses. We also need solutions which fulfill tightness requirements over a very long time. Our experience to date in such matters is very limited.

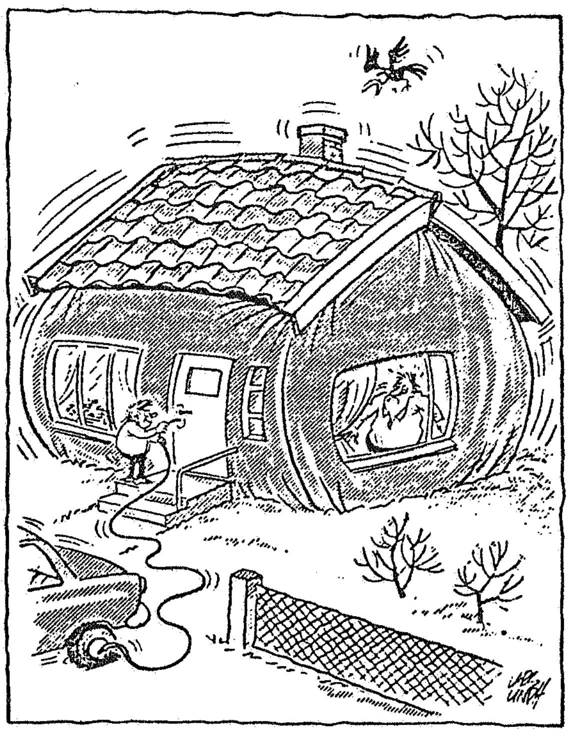
How then do airtight houses function? Studies have been carried out on a number of detached houses which were very airtight—considerably tighter than that required by the building regulations. Studies have also been carried out on a number of houses which have only just fulfilled the stated requirements. In the houses which were very airtight—about 1 air change/hour at 50 Pa—the anticipated energy savings have been achieved by a good margin. Satisfactory building technology, in terms of carefully designed constructions with a high degree of thermal insulation, leads to considerable energy savings. The air quality has been kept to the required level (= 0.5 air changes/hour) almost independently of the outdoor climate merely by the use of an exhaust fan and air supplied via slot air vents in windows in all rooms. Satisfactory ventilation is achieved in all rooms if the speed of the fan is carefully adjusted. The fan's adjustment is of decisive importance for the amount of ventilation. In an airtight house, with carefully regulated ventilation, the ventilation will only vary to a very minor degree in relation to wind velocity and outdoor temperature. Consequently, very airtight houses can function extremely well.

Houses which are less airtight, or which have unsuitable ventilation systems, have sometimes functioned less satisfactorily. Condensation has formed on the inside of windows and, in extreme case, mould problems have been observed. Studies of air change rates in individual rooms in such houses have clearly shown that the ventilation is often quite insufficient. Low air change rates, which are quite unhealthy, have been measured in bedrooms. In insufficiently tight houses, uncontrolled air supply through leaks in the house can result in only certain rooms being ventilated in an acceptable manner. Houses with an air change rate of 3.0 changes/hour at 50 Pa provide an example. Exhaust air ventilation installed in the traditional manner in such detached houses is an example of ventilation design which can lead to certain rooms—usually bedrooms—having insufficient ventilation despite the house as a whole having the recommended average ventilation rate.

Only in sufficiently airtight houses can the ventilation be controlled and regulated to the required level in each section of the dwelling. Airtight houses are also necessary if heat recovery from the ventilation system is to function well and profitably. It is possible to build airtight houses today even if methods need to be further improved.

Standards and knowledge, of how a functioning ventilation system is to be designed for different airtight houses, are however incomplete. A considerably greater degree of collaboration between installation and building technology is necessary if we are to produce low-energy houses with good air quality and if we are to avoid mistakes and unnecessary damage.

BUILD TIGHT—VENTILATE RIGHT.



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