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Progress and Trends - 10th AIVC Conference

25-28th September 1989, Hotel Dipoli, Espoo, Finland

Conference Report by James Piggins, AIVC

The 10th AIVC Conference was opened, with a brief welcome to delegates from Martin Liddament head of the AIVC. Martin then introduced the chairperson of this first session; Marianna Luoma of the Technical Research Centre of Finland. The keynote speaker was Mr. Kari Rahkamo, Chairman of the City Council of Helsinki and the Finnish Association of Heating, Piping & Air Conditioning Societies. In his address he welcomed the conference to Finland, explaining how important ventilation and infiltration are to Finland, a country which experiences great extremes of climate, and how an extensive research program is in progress in these fields. Mr. Rahkamo also welcomed the cooperation between countries inspired by the IEA and its usefulness to his country in complementing Finland's own research programs. Finally he wished all delegates a useful and productive conference, hoping that we would find time in the tight schedule to see some of the sights of Helsinki and the colourful Finnish autumn.

Following the keynote speech, Marianna introduced a series of speakers detailing relevant work in related IEA Annexes. Firstly Prof.Hugo Hens from the KULeuven, Laboratory of Building Physics in Belgium presented a paper on the work of Annex 14 - "Condensation and Energy". This paper focused on energy conservation and good ventilation, to avoid moisture, mould growth and associated health problems in housing. Prof.Hens gave the conference a comprehensive look at the theoretical side of condensation and the related energy aspects. He also detailed the past and present work of the Annex and its future work programme. Next Lars-Goran Mansson from LGM Consult AB of Sweden, presented the work of Annex 18 - "Demand Controlled Ventilation Systems". This Annex is split into three sub-tasks. Subtask A - a review of existing technology, Subtask B - a series of trials of sensors and their locations to find the best sensor and its most appropriate site for any application, the final aim of the Annex being to provide a source book of demand controlled ventilation systems. Thirdly Alfred Moser of the Energy Systems Laboratory, ETH Zürich in Switzerland, gave an entertaining presentation on the work of Annex 20 - "Trends in Airflow Design and Management". His paper concentrated on the need for time dependent airflow simulation to provide the answers for tomorrow's energy efficient building de-

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signers. Annex 20 looks at the tools available and is building the foundations for future work in this area.

Following afternoon tea, Arne Elmroth from the University of Lund in Sweden, presented a paper on ventilation and building design with the major theme of "Build Tight!,Ventilate Right!". This was followed by Max Sherman from the Lawrence Berkeley Laboratory, U.S.A., presenting "Developments in Tracer Gas Techniques", which summarised the major techniques and the relevant error analysis appropriate to each. Jorma Sateri from the Helsinki University of Technology in Finland, described the performance of the passive perfluorocarbon method. The technique was found to be accurate to within 20% and was recommended for use in health and comfort studies of occupied dwellings. Bernard Fleury from ENTPE LASH of France described an experimental study of air flow patterns in a three bedroomed house. This was a pressurisation investigation which tested the leakage of the interior door of the dwelling as well as the exterior/interior leakage.

Monday evening saw the conference delegates enjoying a guided coach tour through the new city of Espoo to a reception at the town hall. An informative slide presentation about the city was held in the council chambers, and was introduced by Deputy Mayor Illppo Aarnio. This was followed by an enjoyable light buffet, which gave the delegates the chance to renew old acquaintances and get to know new delegates and their Finnish hosts in a relaxed atmosphere away from the conference.

Session Two on Tuesday morning was chaired by Mark Riley of Energy Mines and Resources, Canada. This session began with a presentation by Patrick O'Neill from the University of Illinois, who spoke on multizone flow analysis and zone selection using a new pulsed tracer gas technique. Unusually this method uses a single tracer gas to dope the zones. Various simulations have been used to validate the method. The second paper of the morning was presented by Helmut Feustel of the Lawrence Berkeley Laboratory U.S.A., and was entitled "Mathematical Modelling of Infiltration and Ventilation". This consisted of a survey and overview of the models at present in use. Jean-Marie Fürbringer, of EPFL-Bâtiment LESO in Switzerland, then presented a paper concerning the validation of a multizone air infiltration program with a set of full scale measurements. A discussion of the issues and problems of measuring wind data, the paper covered analytical verification, inter-model comparison and empirical validation. The fourth paper of the morning was presented by Peter Nielsen of the University of Aalborg, Denmark. This dealt with air flow simulation techniques, showing the effect that reduced computing costs are having on the field and looking at some of the possibilities for the future.

Continuing the morning session, Carl-Eric Hagentoft of the University of Lund in Sweden, presented a coupled air flow and heat conduction model for mechanically ventilated foundations, which examined a particular Swedish problem of rising damp in foundations. Various air supply and fan position options have been been simulated to find the best solution. Marco Masoero from the Polytechnic of Torino, Italy, presented a paper concerning minimum ventilation rates to prevent surface condensation, which described a case study of two flats on opposite sides of a building, one north facing, one south. Occupant behaviour was found to be a major factor in the effective control of condensation. "An Experimental Method to Measure 3D Air Velocity" was introduced by Peter Nielsen of the University of Aalborg in Denmark. This detailed a novel method of flow visualisation using bubbles, light screens and appropriate photographic techniques, to map the movement of the bubbles with time. David Harrje of Princeton University U.S.A., showed how airflow measurement techniques could be applied to radon mitigation problems. The final paper of this session "Wind Pressure on Low Rise Buildings - An Air Infiltration Analysis", was given by Jan Gusten from Chalmers University of Technology, Sweden. This analysed the interactions between

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Editor: Janet Blacknell

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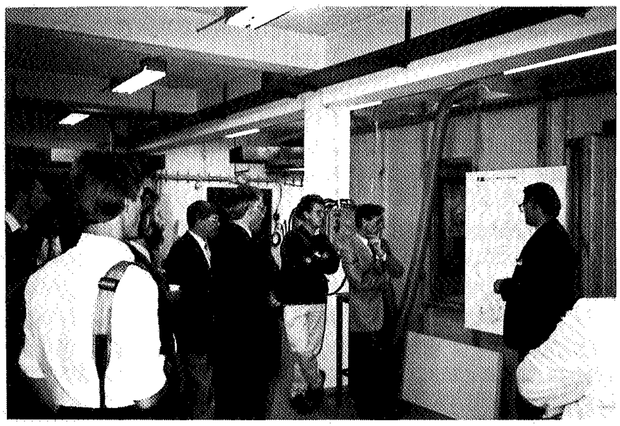
wind pressure fluctuations and the building structure, which can alter the expected infiltration rate calculated from the wind pressure mean.

Tuesday afternoon afforded the delegates a chance for a pleasant walk in the sun, as a technical visit had been arranged to three centres of interest on the research campus. The staff of the Helsinki University of Technology, Laboratory of Heating and Ventilation gave a number of interesting informal presentations on the work of the laboratory. Included in the tour was a Constant Concentration Technique ventilation measurement apparatus and three test rooms, one of which had been used for a paper presented at the conference concerning the use of the Passive Perfluorocarbon Method of ventilation measurement. Several studies were described aimed at improving occupant comfort by establishing minimum healthy ventilation rates and also the correct air velocity and position for fresh air supply registers. Work is also being done on the effectiveness of displacement ventilation.



Technical visit to Helsinki University of Technology

The delegates also visited two sites belonging to the Technical Research Centre of Finland. The structure of the organisation was explained and a brief description and short demonstration given of the air flow simulations in use in the laboratory. This was complimented by a visit to the research centre's most recent acquisition, a new underground research hall. This huge facility has a floor area of over 15000m^2. The delegates were shown round the Research Hall for Acoustics, just one of the five halls all dedicated to various aspects of building technology. This hall comprises a test hall (800m^2), a machine room (350m^2), a silencer space (150m^2) and a single reverberation room soon to be joined by a second. The hall is used for all types of acoustic work for buildings, structures and HVAC systems, and is also used for other forms of performance testing of equipment.

Tuesday evening was devoted to the first of two well attended poster sessions, a brief introduction being given by the chairman of this session Marco Masoero of Italy. This was a highly successful evening with much interest being shown, not least because for the first year delegates were being asked to vote on the best poster and presentation of the conference. The presenters and subjects of this first session were as follows:

Bjorn Kvisgaard of Bruel & Kjaer (Denmark) -Accuracy and Development of Tracer Gas measurement Equipment.

Raimo Niemela of the Institute of Occupational Health (Finland) -A Comparison between the Step-Up, Step-Down and Pulse Injection Techniques for the Measurement of the Mean Age of Air.

Saffa B.Riffat from Loughborough University (UK) -The Developement of a Microprocessor-Controlled Tracer Gas System and Measurement of Ventilation in a Scale Model.

Italo Meroni from ICITE (Italy) -Methodologies for the Evaluation of Ventilation Rates by Tracer Gas Comparison.

Rodger Edwards of UMIST & Christopher Irwin of Willan Building Services Ltd. (UK) -A Comparison of Different Methods of Calculating Interzonal Airflows from Multiple Tracer Gas Decay Tests

Walter Braun of Geilinger Ltd. (Switzerland) -A Modern Concept for Office Buildings; Energy Saving and Good Indoor Climate are No Longer Contradictory.

Agneta Olsson-Jonsson from the Swedish National Testing Institute (Sweden) -Air Change in Flats With natural Ventilation: Measurements and Calculations.

Goran Werner of AIB Antaggningsteknik AB (Sweden) -An Outdoor Air Inlet Without Draught Problems

Per Ake Wickman of EHUB/KTH (Sweden) -Energy Use for the Transport of Ventilation Air

Greg Powell from the University of Wales College, Cardiff (UK) -Comparison of Air Infiltration Rate and Air Leakage Tests Under Reductive Sealing for an Industrial Building.

Robert Bracconier of INRS (France) -General Features of the Two Dimensional Isothermal Mean Flow Inside a Room With a Wall-Mounted Obstacle -A Comparison Between Experimental and Numerical Conditions

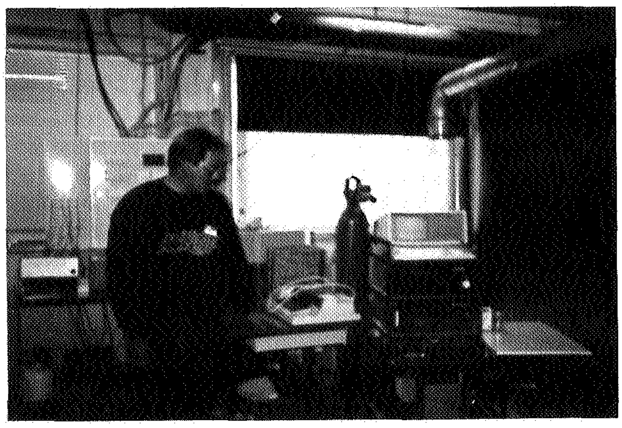
Reza Mokhtarzadeh from Brunel University (UK) -Buoyancy Driven Air Flow in a Closed Half-Scale Stairwell Model -Velocity and Temperature Measurement.

Lauri Heikkinen of PI-Consulting Ltd (Finland) -The Simulation Model of Industrial Air Conditioning Systems.

Pertti Rantanen of Halton Oy (Finland) -VAV -Duct Systems -Simulating.

Bjorn Hedin of Lund Institute of Technology (Sweden) - Identification Methods for Multiple Cell Systems.

Helmut Feustel of the COMIS Group -Description of the COMIS Program.



Demonstration at Conference Technical Visit

The Wednesday morning session was chaired by Jorn Brunsell from the Norwegian Building Research Institute. The first paper of the morning was given by Ake Blomsterberg of the Lund Institute of Technology, Sweden, and was entiltled "Ventilation and Airtightness in Energy Balance Analyses". This examined the ventilation systems in six different modern houses, using the constant concentration technique, single and multizone models to show that energy balances, based on constant assumed values of exfiltration are not accurate. The second paper of the day, "The Performance of Residential Ventilation Systems", given by Risto Ruotsalainen of Helsinki University of Technology in Finland, concerned a ventilation survey of fifty houses. This utilised the decay method for spot measurements, the passive perflourocarbon method for longer term measurements. A simultaneous questionnaire was carried out to determine the effect of ventilation rate on health. A significant correlation was found between typical sick building symptoms and ventilation rate but not with different ventilation types. Don Fugler from the Canada Mortgage & Housing Corporation, described a survey of the performance of exhaust equipment, ducting and chimneys for safety and effectiveness, in "The Performance of Residential Ventilating Equipment with Duct Test Rig". This was followed by morning coffee.

The fourth paper of the morning, "Ventilation by Displacement: Calculation of the Flow in a Three-Dimensional Room" was given by Eric Olsson from Chalmers University in Sweden. This was a description of the comparison between a water box model and a finite difference simulation of displacement flow systems. Reasonably good agreement was achieved. The following paper also took the theme of displacement flow. "Displacement Ventilation for Office Buildings", presented by Beat Kegel of Sulzer Brothers Limited from Switzerland, compared the air velocity and temperature profiles in a test room for winter and summer conditions, with numerical simulations. The transient behaviour of the room was also investigated. A contrasting paper was then given by Earle Perera from BRE in the UK, on the envelope leakiness of large, naturally ventilated buildings which graphically illustrated the differences in construction methods between the UK and the rest of Europe. Although the building stock has improved, the UK still has some way to go to make its industrial buildings as airtight as those in Scandinavia for example. The final presentation of the fourth session, was given by Steve Irving of Oscar Faber Partnership, UK, and was concerned with building energy conservation activities within the International Energy Agency. This presented the work of the AIVC, in relation to the other Annexes of the IEA Energy Conservation in Buildings Programme.

Wednesday evening saw the second of the poster sessions, chaired by Martin Liddament. A major theme of this, session five of the conference, were the developments in each of the member states of the AIVC with a special welcome being made to France which hopes to join as the fourteenth member later this year. A list of presenters and their posters is shown below:

National Summaries:

Peter Wouters	-Belgium
Mark Riley	-Canada
Lutz Trepte	-Federal Republic of Germany
Reijo Kohonen	-Finland
Marc Jardinier	-France
Marco Masoero	-Italy
Willem de Gids	-Netherlands
AIVC	-New Zealand
Jorn T.Brunsell	-Norway
Johnny Kronvall	-Sweden
Peter Hartmann	-Switzerland
Peter Jackman	-United Kingdom
Richard Grot	-United States of America

Other Posters:

Thomas Glimpel of the University of Essen (FRG) -New Design of Central Units in Air Heating Systems for Heating and Ventilation in Domestic Buildings.

Carl Axel Boman of the National Institute for Building Research (Sweden) -Air Changes and Scatter in Mechanical Ventilation Rates in Swedish Residences.

Juhani Laine of the Technical Research Centre (Finland) -Demand Controlled Air Ductwork

Stan Price & Mike Nuess of the Washington State Energy Office (USA) -Public Policy Considerations and the Developement of a Code for the Control of Radon in Residences.

In addition to the posters Mark Limb of the AIVC, gave a demonstration of AIRBASE, the AIVC's bibliographic database, which aroused much interest among the delegates.

The final day of the conference was chaired by Peter Hartmann of EMPA in Switzerland. This began with a presentation by Willem de Gids of TNO in the Netherlands, who gave A Perspective on the AIVC. This was followed by three simultaneous discussion sessions covering: Measurement Techniques, chaired by Max Sherman; Standards and Codes, chaired by Lutz Trepte of Dornier GmbH in the Federal Republic of Germany, and Design Guidelines, chaired by Mike Holmes of Arup Research & Development in the UK.

The Measurement Techniques discussion reported by David Harrje focused on new techniques and old problems. Guarded zone techniques and multiple tracer techniques were discussed. Difficulties with calibration and stability of instruments, mixing within zones, inaccuracies due to sample removal and the length of sample lines affecting sample timing were all highlighted.

The Standards and Codes discussion was reported on by Peter Wouters of CSTC/WTCB in Belgium. This highlighted the need for good integration of standards and the necessity of using a performance approach when setting a standard. A complete range of standards should follow the above doctrines and cover the following areas: Stability, Hygiene and Health, Safety, Energy, Acoustics, Fire. The role of the AIVC was discussed, in that it should take an information rather than active role, and help to stimulate and coordinate research by raising awareness of the relevant issues.

Johnny Kronvall of Lund University in Sweden, reported on the third discussion group Design Guidelines. These should promote energy efficiency, air quality, comfort, and cost effectiveness within the context of the prevailing climate. This process should follow the normal research, developement, and design path. Data from measurements and simulations should be developed into design procedure guidelines for common building types. Special building types will still have to return to fundamental principles and data. The role of the AIVC in this process was discussed, its present contribution in the form of the measurement and calculation handbooks being noted. Future contributions in the form of the numerical database and work on simulations will complete the groundwork required for the drawing up of design guidelines and ultimately standards.

Peter Hartmann gave the final summing up of the conference, its usefulness, and friendliness in terms of international cooperation. He also thanked the staff of the AIVC for their work in making the conference possible. Finally Martin Liddament closed the conference with the presentations for best presentation and poster.The best presentation award was won by Alfred Moser for his original presentation of the work of Annex 20, and the best poster award went to Marc Jardinier for his poster on the developement of demand controlled ventilation in France. Martin finished by thanking our Finnish hosts, in particular Marianna Luoma, Paivi Marjamaki and Jouni Haikarainen for their time and effort in organising the conference facilities and making sure that the whole event ran smoothly.

The full proceedings of the conference including discussion notes will soon be available direct from the AIVC, price £35.00 Sterling including postage and packing.

Availability of AIVC Conference Proceedings

Copies of AIVC Conference Proceedings are still available (except the first conference) as follows:

No. 1"Instrumentation and measuring techniques", 6-8 October 1980, Windsor, UK. *Out of print. Available for loan only.*
No. 2 "Building design for minimum air infiltration", 21-23 September 1981, Royal Institute of Technology, Stockholm, Sweden. *£15.00*
No. 3 "Energy efficient domestic ventilation systems for achieving acceptable indoor air quality", 20-23 September 1982, Park Court Hotel, London, UK. *£23.50*
No. 4 "Air infiltration reduction in existing buildings", 26-28 September 1983, Hotel Sardona, Elm, Switzerland. *£16.00*
No. 5 "The implementation and effectiveness of air infiltration standards in buildings", 1-4 October 1984, Reno, Nevada, USA. *£16.00*
No. 6 "Ventilation strategies and measurement techniques", 16-19 September 1985, Het Meerdal, Netherlands. *£22.00*
No.7 "Occupant interaction with ventilation systems", 29 September-2 October 1986, Stratford-on-Avon, UK. *£25.00*
No. 8 "Ventilation technology - research and application", 21-24 September 1987, Überlingen, Federal Republic of Germany. *£25.00*
No. 9 "Effective ventilation", 12-15 September 1988, Novotel, Gent, Belgium. *£30.00*
No. 10 "Progress and trends in air infiltration and ventilation research", 25-28 September 1989, Hotel Dipoli, Helsinki, Finland. *Available shortly - see above.*

Evaluation of an Acoustical Method for Detecting Air Leaks

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1 Abstract

This investigation was performed to evaluate the effectiveness of detecting air leaks in typical constructions through the measurement of sound transmission. The sound transmission of various slits was measured. These were designed to simulate field constructions. Due to the fundamental difference between steady airflow and sound propagation, it was concluded that the method fails, particularly in the case of foil-covered slits and slits coupled to damped cavities.

2 Purpose of the Investigation

The study was undertaken to determine whether an in-situ acoustical measurement could be utilized to trace air leaks. A requirement of the method was the use of everyday sound level meters, thus avoiding the need for sophisticated acoustical instruments in the field. At the outset, a literature survey was performed. The findings are compiled in a bibliography at the end of this article.

A straightforward method proposed in the literature is the measurement of sound transmission: a loudspeaker is placed on one side of the construction and the sound pressure level is measured on both sides with a simple sound level meter located near the surface of the specimen. Slits or holes are indicated by an increase in sound pressure level.

This method was investigated further. In order to obtain quantitative data, the sound transmission was measured using well-defined slits. Slit dimensions and constructions comparable to those found in field constructions were utilized with a view toward future applications.

The following measurements were performed:

1. Sound transmission through simple slits of various widths; 2. Sound transmission through slits containing a rectangular bend; 3. Sound transmission through slits covered with various foils; 4. Sound transmission through slits coupled to a damped cavity.

3 Measurements

The tests were performed in a laboratory facility for the measurement of the sound transmission of doors. The main structural member had a high transmission loss. It was provided with additional elements in the form of slits. Figure 1 shows the main member from both sides. Two large gaps were cut into it. The first gap was then closed by a 10 cm thick wooden beam. This was designated as the "reference beam". The other gap was closed by two beams, thus creating a slit which could be adjusted to different widths.

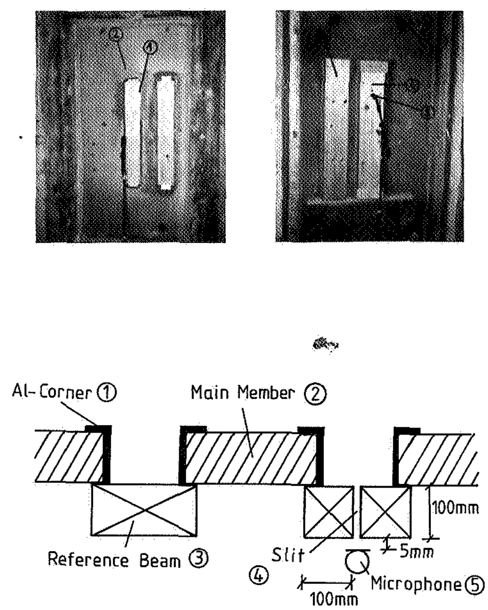


Fig. 1 Illustration and schematic view of main member with the two gaps, and with the reference beam and slit fastened to it.

The average sound pressure level in the sender room was measured. On the opposite side, the sound pressure level was measured at a distance of 0.5 cm from the slit. Sound transmission occurred not only through the slit, but also through the main member itself. In order to correct for the latter sound transmission, the sound pressure level near the surface of the reference beam was also measured.

The measurements were carried out with a real-time 1/3 octave-band analyzer (Norton 830). All bands from 200 Hz up to 10 kHz were considered.

Since the method was intended to detect slits which are not apparent to the naked eye, small slit widths were employed, namely 0.5 mm, 1.0 mm, 1.5 mm and 2.0 mm. The interpretation of the measurements was to be as simple as possible. With this in mind, the difference D_s was defined:

$$D_s = P_1 - P_2$$

where

P_1 = sound pressure level 0.5 cm from the slit
P_2 = average sound pressure level in the sender room.

A similar difference was defined for the reference beam, designated as D_0.

Figure 2 shows the spectrum of the negative D_0 values for the reference beam.

A decrease in D_0 is noted at high frequencies. This is attributed to sound transmission through the slit and other leaks. It results in a rather high sound pressure in the receiver room, thus increasing the apparent sound transmission of the reference beam.

By taking the difference $T_s = D_s - D_0$, the increase in sound pressure due to the presence of the slit is obtained. The results for the various slits are presented below in terms of this quantity Ts. A more accurate way of defining the sound transmission would be in terms of the acoustic energy transmitted through the slit. However, consistent with the goal of trying to detect leaks with a simple sound level meter, only the differences in sound pressure level will be considered here.

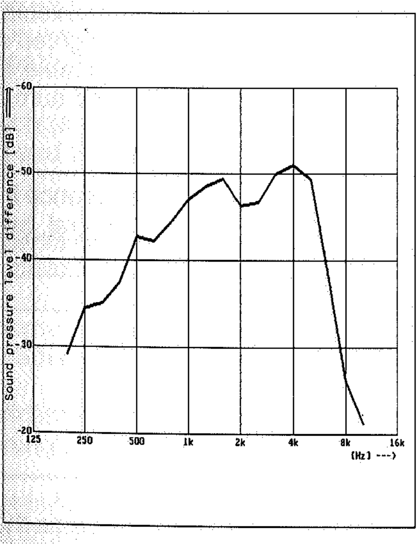
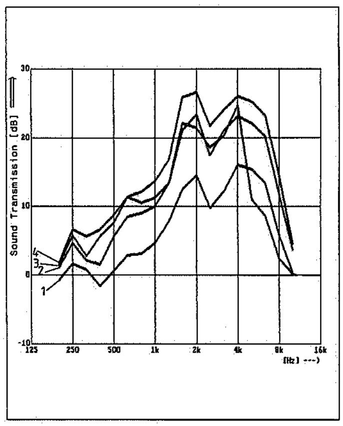


Fig. 2 Spectrum at reference beam compared with sender room (D_0)

The following results were obtained:

Simple slit

Figure 3 shows a sketch of the elements and the results for a simple slit. In accordance with theory, a peak in the sound transmission is observed at approximately 1250-1600 Hz, resp. a dip at 2500 Hz. This dip occurs when the depth of the slit is an integer multiple of the half-wavelength. The peak and dip can also be observed with the other slit types. A further decrease in sound transmission, not explained by theory, is seen at the upper end of the frequency range. This occurs because the quantity T_s represents the difference between the sound pressure at the slit and at the reference beam. As mentioned above, the apparent sound transmission of the reference beam is reduced by the sound transmission of the slit itself, thus in turn reducing the difference T_s.



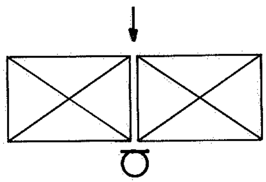


Fig. 3 Sound transmission T_s of simple slits: 1) 0.5mm; 2) 1.0mm; 3) 1.5mm and 4) 2.0mm

Slit containing a rectangular bend

Figure 4 shows a sketch and the results for slits having a rectangular bend. The peak and dip occur at higher frequencies than with the simple slit and are less pronounced. This is due to the more complicated geometrical structure which affects the standing wave buildup.

Slit covered with a foil

Figures 5 and 6 show sketches and results for a simple PE-foil and for roofing paper. Although the slit is airtight, the sound transmission with the PE-foil is not greatly affected.

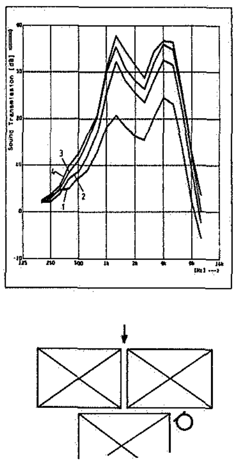


Fig. 4 Sound transmission T_s of slits containing a rectangular bend: 1) 0.5mm; 2) 1.0mm; 3) 1.5mm and 4) 2.0mm

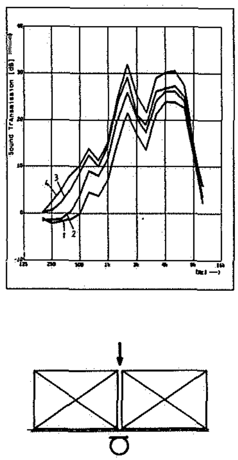


Fig. 5 Sound transmission T_s of slits covered with a PE-foil: 1) 0.5mm; 2) 1.0mm; 3) 1.5mm and 4) 2.0mm

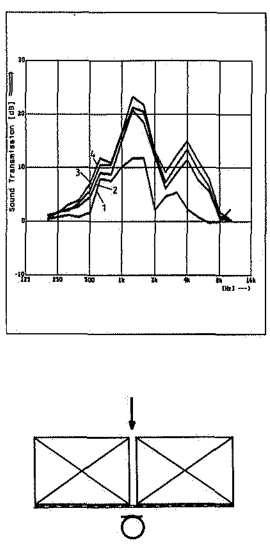


Fig. 6 Sound Transmission T_s of slits covered with roofing paper: 1) 0.5mm; 2) 1.0mm; 3) 1.5mm and 4) 2.0mm

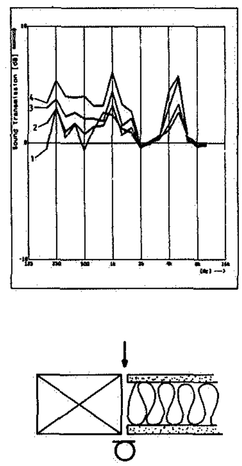


Fig. 7 Sound transmission T_s of slits coupled to a damped cavity: 1) 0.5mm; 2) 1.0mm; 3) 1.5mm and 4) 2.0mm

This measurement clearly illustrates the difference between steady air flow and sound propagation. Lightweight foils represent only a small resistance for the vibrating air molecules (sound), but allow no steady air flow. It is interesting to note that in the case of the PE-foil, the sound transmission is even higher than that for the simple slit. This is possibly due to a better match of the radiation impedance between the slit and room.

Slit coupled to a damped cavity

As seen from Figure 7, the sound transmission is effectively reduced, although air is able to pass freely through the slit. This type of construction is often used for doors, where it is necessary to reduce sound transmission through the slit between the door and the floor.

Discussion

A real-time analyzer is not commonly available for field measurements. Only the linear or A-weighted sound level can be measured. In the following table, the linear difference (calculated from the energetic sum of the 1/3 octave-bands) is presented.

Slit type	Level difference in dB (linear) (slit - ref. beam)
simple slit	11.3
slit with rectangular bend	19.2
covered slit (foil)	12.4
covered slit (roofing paper)	12.1
slit coupled to damped cavity	1.4

These results are somewhat arbitrary, since they depend on the spectrum in the sender room (in this case pink noise). Nevertheless, it is obvious that the overall level differences are neither consistent not reliable. The method fails in two cases which occur frequently in the field.

Indeed, an operator would suspect that a foil was located in or at the end of the slit by examining the spectrum of the sound transmission, as was done during this investigation. However, this contradicts our postulated requirement for a simple method without the need of sophisticated instruments. Likewise, in the case of the slit coupled to a damped cavity, it would require a more elaborate acoustic measurement to establish that a degree of sound transmission was still present.

The method fails because the relation between air-flow and sound transmission (by analogy, DC and AC) is ambiguous. Electrically, the slit with a foil can be compared to a series condenser (block direct flow) and the slit coupled to a cavity to a parallel condenser (reducing AC flow).

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AIDA - an Air Infiltration Development Algorithm

Martin Liddament

Head of Air Infiltration and Ventilation Centre

Introduction

AIDA is a basic infiltration calculation procedure intended for the calculation of air change rates in single zone enclosures. It also determines flow rates for up to 10 user defined openings and calculates wind and stack pressures. This program is very easy to use but, nevertheless, provides an accurate solution to the air infiltration flow balance equation. As its name suggests this is a development algorithm which may be readily adapted to include additional flow paths, mechanical ventilation and many other features. In less than 60 lines of computer code, AIDA is capable of solving almost any single zone problem on almost any level of computer. This algorithm uses the concepts outlined in Chapter 3 of the AIVC's Calculation Techniques Guide (Liddament 1986).

1Theoretical Outline

Solution is based on the iterative balancing of the flow equation given by:

$$Q = \sum_{j=1}^{I} C_j\,(p_j)^{n_j} = 0$$

where j = flow path number
I = total number of flow paths
C_j = flow coefficient of flow path j
n_j = flow exponent of flow path j
Δp_j = pressure difference across flow path j

The external pressure acting on each flow path is derived from the wind pressure, given by:

$$p_w = \rho/2C_pU^2 \text{ (Pa)}$$

and the stack pressure, given by:

$$p_s = -\rho_o g 273h(1/t_e - 1/t_i) \text{ (Pa)}$$

where ρ = air density (kg/m^3)
ρ_o = air density at 273 K
C_p = wind pressure coefficient
h = height of opening (m)
U = building height windspeed (m/s)
t_e = external air temperature (K)
t_i = internal air temperature (K)
g = acceleration due to gravity (m/s^2)

The user defines up to 10 flow paths and enters appropriate flow characteristics, drawing data from knowledge about the building or from the default data presented in Chapter 6 of the AIVC's Calculation Techniques Guide.

2 Program Operation

AIDA is written in BASIC, originally for a CASIO FX730P Pocket Computer. A full listing of this version is presented in Table 1. With minor modifications, however, it will also run on an IBM compatible PC, using either BASIC, GWBASIC or QUICK BASIC. Furthermore, if the QUICK BASIC compiler option is used, convergence is almost instant, and hence this algorithm may prove to be useful as part of a general energy or thermal heat loss model. Suggested amendments to the code for "PC" compatibility are given in Table 2. Initiation of the code will be machine dependent but in the BASIC environment, will normally be achieved by using the "RUN" command. Once the response "Welcome to AIDA" appears on the screen, then the "EXE" or "ENTER" key is pressed sequentially with the user responding accurately to each of the input questions.

Data entry is largely self explicit. The order of entry is:

- Building Volume (m^3)

- Number of Flow Paths

- Height of Flow Path (m)	) These items are
- Flow Coefficient (m^3/s at 1 Pa)	) repeated for each
- Flow Exponent	) flow path.
- Wind Pressure Coefficient	)

- External Temperature (°C)	) These items are
- Internal Temperature (°C)	) repeated as
- Wind Speed	) necessary.
at Building Height (m/s)	)

On completion of data entry, the computer responds with the message "Calculation in Progress". The calculation will take between <1 second for a PC to >60 seconds for the CASIO. After iteration is completed, the infiltration rate is displayed on the screen. If the CASIO machine is used, press "EXE" to display the air change rate and "EXE" again to enter further climatic data, break out of the program by pressing "AC". If the PC version is used, the air change rate and request for further climatic data is automatically displayed, break out of the program by using "CTRL BREAK".

Table 1: AIDA Program Listing for CASIO FX730P

```
10 SET N
20 PRINT "Welcome to AIDA"
30 PRINT "Air Infiltration Development Algorithm"
40 PRINT "M Liddament - AIVC -1989"
50 DIMH(10),C(10),N(10),P(10),T(10),W(10),S(10),F(10)
60 D=1.29 : REM Air Density at 0 Deg C
70 PRINT "Enter Building Data:"
80 INPUT "Building Volume (m3) = ",V
90 PRINT "Enter Flow Path Data:"
100 INPUT "Number of Flow Paths = ",L
110 FOR J=1 TO L
120   PRINT "Height (m)(Path";J;")  = ";: INPUT H(J)
130   PRINT "Flow Coef (Path";J;")  = ";: INPUT C(J)
140   PRINT "Flow Exp  (Path";J;")  = ";: INPUT N(J)
150   PRINT "Pres Coef (Path";J;")  = ";: INPUT P(J)
160 NEXT J
170 PRINT "Enter Climatic Data:"
180 INPUT "Ext Temp (Deg C)      = ",E
190 INPUT "Int Temp (Deg C)      = ",I
200 INPUT "Wind Spd(Bldg Ht)(m/s)= ",U
210 REM Pressure Calculation
220 FOR J=1 TO L
230   REM Wind Pressure Calculation
240   W(J)=.5*D*P(J)*U*U
250   REM Stack Pressure Calculation
260   S(J)=-3455*H(J)*(1/(E+273)-1/(I+273))
270   REM Total Pressure
280   T(J)=W(J)+S(J)
290 NEXT J
300 REM Calculate Infiltration
310   PRINT "Calculation in Progress";
320 R=-100
330 X=50
340 Y=0
350 B=0
360 R=R+X
370 FOR J=1 TO L
380   Y=Y+1
390   O=T(J)-R
400   IF O=0 THEN F(J)=0: GOTO 430
410   F(J)=C(J)*(ABS(O)^N(J))*O/ABS(O)
420   B=B+F(J)
430 NEXT J
440 IF B <0 THEN R=R-X: X=X/2: GOTO 350
450 IF B < 0.0001 THEN GOTO 470
460 GOTO 350
470 Q=0
480 FOR J=1 TO L
490   IF F(J)>0 THEN Q=Q+F(J)
500 NEXT J
510 SET F5
520 PRINT: PRINT "infiltration rate (m³/s) = ";Q
530 A=Q*3600/V
540 PRINT "air change rate (ach)    = ";A
550 GOTO 170
```

At the completion of a session, the most recent data remains in store and can be recovered by entering the appropriate variable letter (CASIO) or by using the "PRINT" command (PC version).
Examples: (CASIO)

press "Q" followed by "EXE" to display infiltration rate
press "F(2)"followed by "EXE" to display flow in path 2

(PC version)

PRINT Q displays infiltration rate
PRINT F(2) displays flow in path 2

Table 2: Amendments for MSDOS (IBM Compatible) Operation

```
10 REM SET N
15 CLS
55 PRINT:PRINT:PRINT
85 PRINT:PRINT:PRINT
115 PRINT:PRINT:PRINT
165 PRINT:PRINT:PRINT
175 PRINT:PRINT:PRINT
305 CLS:PRINT:PRINT:PRINT
505 PRINT:PRINT:PRINT
510 REM SET F5
545 PRINT:PRINT:PRINT
```

Note: These amendments remove the CASIO "SET" commands and improve the interactive display.

All the variables used in the algorithm are listed in Table 3.

Data must be inserted with care since there is no error trapping or editing facility. If an error is made, then it is necessary to restart the program.

Clearly, since this is primarily a pocket computer algorithm, the interactive Input/Output routine is very rudimentary. It is assumed that if wider use is made of the "PC" version, then the user will amend these routines to suit individual requirements.

3 Solution Technique.

The flow balance equation is solved iteratively using a combination of "bi-section" and "addition". An internal pressure, known to be substantially negative with respect to the true pressure, is selected as a starting condition. For most applications a value of -100 Pa should be satisfactory and is automatically introduced at line 320. Successive iterations improve upon the internal pressure value until a flow balance within 0.0001 m^3/s is

Table 3: AIDA List of Variables

A	= Air Change Rate (ACH)
B	= Flow Balance
C(J)	= Flow Coefficient (Path J)
D	= Air Density (kg/m^3)
E	= External Temperature (Degrees C)
F(J)	= Calculated Flow Rate (Path J) (m^3/s)
H(J)	= Height of Flow Path (Path J) (m)
I	= Internal Temperature (Degrees C)
J	= Flow Path Number
L	= Total Number of Flow Paths (Max = 10)
N(J)	= Flow Exponent (Path J)
O	= Pressure Difference across flow path (Pa)
P(J)	= Wind Pressure Coefficient (Path J)
Q	= Infiltration Rate (m^3/s)
R	= Internal Pressure (Pa)
S(J)	= Stack Induced Pressure (Path J) (Pa)
T(J)	= Total External Pressure on Flow Path (Path J) (Pa)
U	= Wind Speed at Building Height (m/s)
V	= Volume of Building or Enclosure (m^3)
W(J)	= Wind Induced Pressure (Path J) (Pa)
X	= Iteration Pressure Step (Pa)
Y	= Iteration Counter

achieved.The flow balance criterion is established in line 450. An understanding of the technique may be gleaned from an analysis of lines 320 to 470 of the program. While this approach may not necessarily be the most numerically efficient, it is extremely robust and should be applicable over a wide range of flow conditions and leakage characteristics.

4 Example

Input data and results for a 3 flow path network are presented in Table 4. Although this is an arbitrary example, it has been selected to show that AIDA can handle differing flow coefficients, flow exponents, flow path heights and wind pressure coefficients within the same network.

5 Program Developments

Developments covering mechanical ventilation, additional flow paths, automatic wind pressure distributions and wind speed correction equations may be readily incorporated. It is intended to cover some of these developments, along with validation tests in future issues of "AIR".

6 References

Liddament, M.W. Air Infiltration Calculation Techniques - An Applications Guide. Air Infiltration and Ventilation Centre 1986.

Table 4: Example Data and Results

Building Volume = 250 m^3
Number of flow paths = 3

	Path 1	Path 2	Path 3
Height of Path (m)	2	4	7
Flow Coef (m^3/s at 1 pa)	0.03	0.06	0.02
Flow Exponent	0.7	0.5	0.6
Wind Pressure Coef	0.3	-0.25	-0.4
Climatic Data	Ext Temp (Deg C)	Int Temp (Deg C)	Wind Speed (m/s)
Run 1	0	20	0
Run 2	5	15	2
Run 3	18	18	3

Results:

	Infilt Rate (m^3/s)	Air Ch Rate (ach)	Flow (Path 1) (m^3/s)	Flow (Path 2) (m^3/s)	Flow (Path 3) (m^3/s)
Run 1	0.0437	0.63	0.0437	-0.0081	-0.0356
Run 2	0.0511	0.74	0.0511	-0.0224	-0.0287
Run 3	0.0615	0.89	0.0615	-0.0382	-0.0232

Final Reminder - AIVC Survey of Research

Replies are still being accepted for the AIVC Survey of Current Research into Air Infiltration and Ventilation 1989. Your completed survey form will be entered on a database and published in the form of an AIVC Technical Note.

The Technical Note is automatically distributed to all researchers listed, thus guaranteeing free publicity for your particular project in all thirteen participating countries of the AIVC.

The Survey database will be available for distribution on Archivist software, as part of the AIVC "Airbase" package of diskettes.

Any outstanding Survey Forms should be completed and returned, preferably by telefax, to Mark Limb at AIVC as soon as possible.

Report on the 8th World Clean Air Congress "Man and his Ecosystem"

Den Haag (The Netherlands), 11-15 September 1989

Marco Masoero - Politecnico di Torino (Italy)

Just two weeks before the 10th annual AIVC Conference, another important gathering of researchers and professionals in the air quality field took place in Den Haag, the Netherlands.

The 8th World Clean Air Congress -- a triennial event -- marked the 25th anniversary of the International Union of Air Pollution Prevention Associations (IUAPPA). At present, IUAPPA comprises 19 member and 6 observer associations, representing countries from every continent.

After the plenary introductory session on Monday morning, for the following four days the attendees were kept busy with parallel technical sessions, one afternoon of field visits in the Rotterdam industrial area, and the concurrent product exhibition.

A few figures to quantify the importance of the event: approximately 500 delegates from 38 different countries attended the conference; over 350 papers or posters were presented; 56 companies were present in the exhibition.

Topics covered by the conference were organized into five broad themes:

Theme A: "MAN"
- Human health and dose-response relationships
- Psycho-social effects

Theme B: "INDOOR AIR"
- Air quality in relation to occupational health
- Air quality in public buildings, the home and the car

Theme C: "ANIMALS AND PLANTS, MATERIALS"
- Biological effects
- Acidification
- Effects on materials

Theme D: "THE SYSTEM"
- Monitoring
- Air pollution meteorology
- Air pollution chemistry
- Aerosols
- Instrumentation

Theme E: "THE MAN-MADE SYSTEM"
- Policy towards clean air
- Emissions, air pollution control
- Integrated approach to control
- Economic aspects: costs and benefits
- International cooperation and international law.

Although the majority of the sessions were mostly or exclusively concerned with the outdoor environment, theme B "Indoor Air" was certainly of great interest for people like myself, active in ventilation and indoor air quality control.

A further element of interest was the emphasis and perspective of the papers presented at the World Clean Air Conference, quite different from what is normally found at meetings of organizations such as AIVC, ASHRAE or CIB. While in the latter case the most usual authors' affiliation is with research or professional bodies in the civil or mechanical engineering field, the Clean Air conférence was attended mostly by people active in the sectors of environmental sciences or engineering, public or occupational health, and environmental policy.

Such differences in background and professional interests is clearly reflected in the selection of the topics that were covered in the papers.

A first group of papers addressed issues related to occupational health, such as the medical consequences and the proposed mitigation strategies in particularly critical working environments such as metallurgical plants, flour mills, and even army installations.

Very few of the papers addressed policy issues in relation to indoor air quality control, in contrast with the abundant wealth of similar papers on outdoor pollution monitoring and control policies.

Five papers, presented by researchers in the health field, were concerned with the medical effects of typical indoor pollutants: primary emphasis was placed on volatile organic compounds (VOC), nitrogen oxides (NOx), formaldehyde, and biological agents (fungi and bacteria); surprisingly rare were the references to the radon problem.

Several of the papers were more or less directly addressing the "Sick Building Syndrome" issue, some from a medical viewpoint, some from the engineering side (particularly, discussing possible mitigation strategies such as air ionization and the use of chemical additives in air handling equipment).

However, the bulk of the papers (roughly two thirds of the total) dealt with field assessments of IAQ in a number of different building categories (residential buildings, office spaces, schools, swimming pools) and in private and public transportation systems (cars, buses, metros, etc.). Some of the papers presented innovative instrumentation or experimental techniques, and even numerical simulations of indoor pollution.

Many of the papers analysed the causes of indoor pollution: emission of polluted outdoor air (particularly of traffic origin -- NOx, lead, particulates), use of unvented combustion appliances, and emission from furnishing or building materials.

The quality of the papers was usually good, and my personal overall evaluation of the World Clean Air Conference is extremely positive: it was an excellent occasion for meeting colleagues from different countries and backgrounds, and for getting a broad and exhaustive overview of the state of the art in the field of air quality.

Air Infiltration Modelling Comparisons with Measured Data in Houses

by James T Reardon

Institute for Research in Construction, National Research Council of Canada, Ottawa

Introduction

This article briefly describes the results of a study comparing three existing models of air infiltration for detached houses [1,2]. The study was carried out as a collaborative project by the Institute for Research in Construction of the National Research Council of Canada (NRC) and Energy, Mines and Resources Canada (EMR). The objective was to identify the best model, in terms of accuracy and simplicity, for later use in the development of a ventilation assessment prescriptive procedure (VAPP). Measured data formed the basis for the model comparisons.

The VAPP was being developed by EMR for use by the energy conservation retrofit industry. Air sealing contractors need a simple and accurate method to estimate the air infiltration rate in a house to ensure that their retrofit work will not negatively affect the indoor air quality. The VAPP was intended to provide this tool to the industry. The results of this project, and the VAPP, may also provide a technical basis for the development of ventilation standards and guidelines for houses in Canada.

Models

The three models that were tested were the Lawrence Berkeley Laboratory (LBL) model [3], the National Research Council of Canada model [4], and the variable flow exponent (VFE) model [5]. All these models treat the house as a single, well-mixed cell. Each model uses one or two model parameters to describe the overall airtightness of the house and one or two parameters to describe the vertical distribution of the leakage area over the building envelope. The infiltration contributions due to stack effect and wind are modelled separately and then combined using some form of quadrature. The VFE model was originally developed as a general case of the LBL model, in which the flow exponent in the relationship between envelope pressure and leakage flow rate was allowed to take the value resulting from a fan depressurization test of the house, rather than the square root, orifice flow-type, relationship used in the LBL model.

A new model, called the VFECFn model, combining some of the features of the other three models was developed in the course of this study. Rather than simply modify the flow exponent as the VFE model did, the new model replaced the orifice flow relationship in the LBL model with the general power law pressure/flow relationship measured by a blower door test, before integrating the pressure field over the building envelope. The NRC model's weighting scheme for combining the stack effect and wind-driven model components was also incorporated in the new model to account for the interaction between the pressure differences caused by wind and stack effect [6].

Measured Data

Sixteen houses in Ottawa and seven houses in Winnipeg were involved in the tests. All the houses were of wood frame construction with full basements and had forced air heating systems fuelled by oil, natural gas or electricity. They ranged in age from 1912 to 1980, and in size from small bungalows to fairly large two-storey houses with full attics, including split-levels. The sample of houses covered the full range of typical detached, single-family, Canadian housing.

During the late summer and fall of 1987, the airtightness of each house was measured using the fan depressurization technique. The CGSB standard procedure [7] was followed with the exception that closable vents and flue dampers were closed but no extraordinary measures were taken to seal leakage openings. The object was to test the houses under normal operating conditions.

The neutral pressure levels (NPL), defined as the ratio of the height of neutral pressure (zero pressure difference between inside and outside due to stack effect) to house height, were measured in all 23 test houses during the early winter of 1988. Neutral pressure levels have rarely been measured in other studies due to the small pressures involved and the difficulty of obtaining suitably calm wind conditions. Electronic, high-resolution manometers and a strip chart recorder to assist signal averaging were used for these measurements.
Air infiltration rates were measured in the houses twice weekly during the fall, winter and spring seasons of 1987/88 using the tracer gas decay technique. Sulphur hexafluoride was used as the active tracer gas and grab sampling was used to collect air samples. Those samples were analyzed using an electron capture gas chromatograph in the laboratory. For each test, samples were collected at two or three locations in each house to provide a check on the mixing. A total of 810 air infiltration measurements were made during the project.

Comparisons of Predictions with Measurements

The measured air infiltration rates were compared with model predictions. As it is not practical to expect contractors to measure on-site weather conditions, weather data measured at the local airport were used in the model calculations. Certain model input parameters could not be measured, and in those cases, default values were used in the calculations. For example, the vertical leakage distribution parameters R and X in the LBL model were assigned the values 0.5 and 0.0 respectively, in accordance with LBL publications [8,9]. LBL shielding and terrain parameters were assigned values according to their descriptions.

Two publications [1,2] describe in detail the entire comparisons for two cases of model calculations: with measured neutral pressure levels and with default NPL values. The default NPL values were determined from the comparisons, various statistical measures of agreement between calculations and measurements were used to rank the models' accuracies.

The overall accuracy of the LBL, NRC, and VFECFn models was found to be good, and very similar. The accuracy of the VFE model was the poorest. The statistical measures used to assess each model's performance indicated that the NRC model offered the best overall accuracy by a small margin over the VFECFn model, followed closely by the LBL model.
Of the various models tested, the NRC model was the simplest to use, having the fewest input parameters to be determined by a user. Default values for the NPL parameter were found to perform well in the calculations. The LBL model uses leakage distribution parameters which cannot be measured (default values are always used) and terrain and shielding parameters which are not simple to determine. The VFE and VFECFn models both use the same leakage distribution, terrain and shielding parameters as the LBL model, and therefore are similarly complex to use.

Conclusions

Of the existing models tested, the NRC and LBL models offer the best prediction accuracy. Their performance is similar enough that neither one is a clear winner in accuracy. The NRC model is the simplest to use, and therefore was recommended to Energy, Mines and Resources Canada as the basis for the VAPP development.

References

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11th AIVC Conference

Ventilation System Performance

Advance Notice and Call for Papers

Venue: Northern Italy

Date: 18th - 21st September 1990

Over recent years many new ventilation systems have been introduced in order to meet increasing air quality and comfort requirements in both the homes and work places. The objective of the AIVC's 11th Annual Conference is to focus on the performance of modern systems. Both natural and mechanical systems will be covered with special emphasis on:

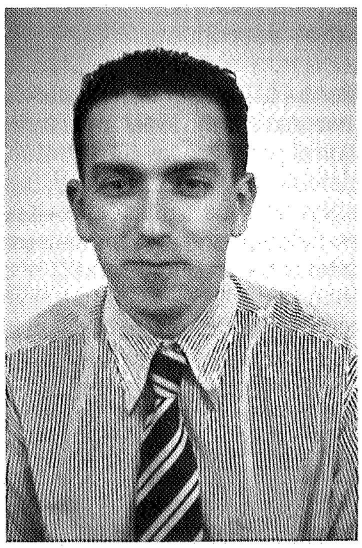
- Design
- Air Quality and Health Requirements
- Energy Effectiveness
- Commissioning
- Performance and Reliability
- Maintenance
- Case Studies

Abstracts, not exceeding 200 words, of proposed papers on the above topics are welcome and should be received by the AIVC no later than 31 January 1990. The abstracts will be subjected to review in March 1990 and print ready copies of accepted papers will be required in July 1990. Submissions from the non-AIVC participating countries are welcome and, if the abstracts are accepted, the authors will be invited to participate in the conference.

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

Programme and registration will be published in the May 1990 edition of AIR. Booking forms will be obtainable from your Steering Group Representative.

New AIVC Staff - James Piggins



James joined the group at the beginning of August. He has a first degree in Applied Science from Kingston upon Thames Polytechnic and an MSc in Energy Conservation from Cranfield Institute of Technology. For the last four years he has been working for British Gas, Watson House Research Station in the Aerodynamics Section. He has been involved in ventilation measurements using both constant concentration and decay methods, and has also carried out pressurisation leakage measurements. These have been carried out in industrial and domestic buildings, both single and multi-cell. More recently, he has been involved in studying the performance of mechanical ventilation and heat recovery systems, logging field data and carrying out comprehensive data analysis. This experience makes him ideally suited to play an important role in the AIVC's on-going programme of work.

Review - Alaska Craftsman Home

Building Manual (Second Edition)

August 1988, A Guide for Energy-Efficient Home Building in Alaska

Published by University of Alaska Cooperative Extension Service, Editor, Richard D Seifert

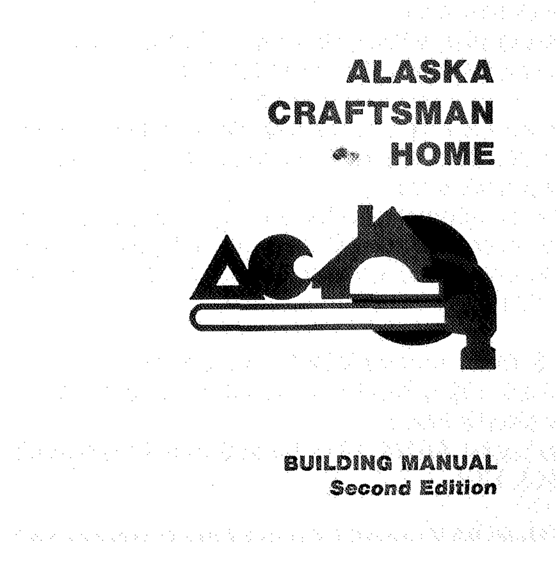
The Alaska Craftsman Home Program (ACHP) is an educational network intended to keep the building industry in Alaska informed of the advances in the way homes are being built in cold climates, both in other parts of the USA and in other parts of the world. Developed two years ago, it is modeled after the Canadian R-2000 program, and is a joint project between the Alaska Homebuilders Association, University of Alaska Cooperative Extension Service, and the State of Alaska.

ACHP holds workshops throughout the State of Alaska to inform builders of the state of the art energy efficient building techniques available for their specific climatic conditions. ACHP also maintains a statewide network to provide technical information to builders. In addition, ACHP tests and certifies the homes built to ACHP standards and assists the builders with marketing. The main steps of certification involve passing a blower door air leakage test and computer analysis of energy requirements using the Canadian HOT-2000 program. In addition, a mechanical ventilation system which can provide fresh air to each room must be provided to meet the ACHP requirements. A home built to ACHP standards will require only 20% of the heating energy of a similar home constructed using conventional building techniques.

The technical manual offers to Alaska's building industry and homeowners an information base of building science principles. The entire content - text, tables, and figures - is intended to clarify the principles of building science.

Sections are as follows:

- Introduction
- Energy
- Building Science
- Regional Determinants
- Design
- Foundations
- Walls
- Attics and Roofs
- Windows and Doors
- Ventilation
- Heating Systems
- Retrofit
- Business Management
- Marketing



Copies of this manual are available from the following address:

Alaska Craftsman Home Program
Cooperative Extension Service
207D Eielson Building
University of Alaska
Fairbanks, Alaska 99775-5200
USA

Forthcoming Conferences

ASHRAE Winter Meeting 1990
February 10-14, 1990, Atlanta, Georgia, USA
Further details from:
Meetings Department, ASHRAE, 1791 Tullie Circle NE, Atlanta, GA 30329 USA Tel: 404/636-8400

Application of Artificial Intelligence and Robotics in Building, Architecture and Civil Engineering, Europia 2nd European Conference
March 15-16,1990 Liège, Belgium
Further details from:
Professor A. Dupagne, LEMA-ULG, 15 Ave des Tilleuls, Bât D1, B-4000 Liège, Belgium

ASME International Solar Energy Conference "Design Tools for Passive Solar and Building Energy Conservation"
April 1-4, 1990, Miami, Florida, USA
Further details from:
Dr P Monaghan, Dept of Mechanical Engineering, University College Galway, Ireland

Facilities Management International Conference "Delivering Quality and Value in Buildings in an International Market"
April 9-13, 1990, Glasgow, Scotland
Further details from:
Keith Alexander, BPRU, University of Strathclyde, 131 Rottenrow, Glasgow, Scotland G4 ONG

Indoor Air Quality and Ventilation in Warm Climates
April 24-26, 1990, Sheraton Hotel, Lisbon, Portugal
Further details from:
Secretariat, International Indoor Air Quality and Ventilation Conference, British Occupational Hygiene Society, 1 St Andrews Place, London NW1 4LB, United Kingdom Tel: 01 823 9401

ASTM Subcommittee D22.05 on Indoor Air
April 25-26, 1990, San Francisco, California, USA
Further details from:
George Luciw, ASTM, 1916 Race Street, Philadelphia PA 19103, USA

Room Vent 90 Second International Conference Engineering Aero and Thermodynamics of Ventilated Rooms
June 13-15, 1990, Oslo, Norway
Further details from:
Room Vent, c/o Norsk VVS Teknisk Forening, PO Box 5042 Maj, N-0301 Oslo 3, Norway Tel: 47 2 60 13 90

FITAT International Symposium
16-18 July 16-18, 1990, Lyon, France
Further details from:
FITAT, 34 rue de la Charité, 69002 Lyon, France Tel: 33 72 40 23 95

The 5th International Conference on Indoor Air Quality and Climate
July 29 - August 3, 1990, Metro Toronto Convention Centre, Toronto, Canada
Further details from:
Indoor Air 90 Centre for Indoor Air Quality Research, University of Toronto, 223 College Street, Toronto, Ontario, Canada M5T 1R4 Tel: 416) 978 8605

Energy, Moisture, Climate in Buildings
September 3-6, 1990, Rotterdam, The Netherlands
Further details from:
Mr G de Vries, Bouwcentrum Weena 760, P O Box 299, 3000 AG Rotterdam, The Netherlands

Ventilation System Performance
11th AIVC Conference
September 18 - 21,1990, Italy
Further details from:
Dr Martin Liddament, AIVC

Applications and Efficiency of Heat Pump Systems in Environmentally Sensitive Times
September 18-21, 1990, Munich, Fed.Rep. of Germany
Further details from:
Lorraine Grove - Organiser, Heat Pumps Conference, BHRA, The Fluid Engineering Centre, Cranfield, Bedford MK43 0AJ, United Kingdom

Indoor Radon and Lung Cancer:Reality or Myth?
29th Hanford Symposium on Health and the Environment
October 16-19, 1990, Richland, Washington, USA
Further details from:
Fred T. Cross, Symposium Chairman, Battelle PNL, P O Box 999, Richland, WA 99352, USA Tel: (509) 375-2976

3rd International Conference on System Simulation in Buildings
December 3-5, 1990, Liège, Belgium
Further details from:
Georges Liebecq, University of Liège Laboratory of Thermodynamics, Rue Ernest Solvay, 21, B-4000 Liège, Belgium Tel: 32-41-52.01.80

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PERIODICALS

Air Infiltration Review Quarterly newsletter containing topical and informative articles on air infiltration research and application. Unrestricted availability, free-of-charge.

Recent Additions to AIRBASE Quarterly bulletin of abstracts added to AIRBASE, AIVC's bibliographic database. Bulletin and copies of papers available free-of-charge to participating countries* only.

GUIDES AND HANDBOOKS

Applications Guide 1 (1986) Liddament, M.W. 'Air Infiltration Calculation Techniques - An Applications Guide' A loose-leaf handbook divided into six chapters covering empirical and theoretical calculation techniques, algorithms, references and glossary of terms. Available free-of-charge to participating countries* only, via your national Steering Group representative.

Applications Guide 2 (1988) Charlesworth, P.S. 'Air Exchange Rate and Airtightness Measurement Techniques - An Application Guide' A loose-leaf handbook divided into seven chapters covering air change rate, interzonal air flow and building airtightness measurement techniques.

TECHNICAL NOTES

5 (1981) Allen, C. 'AIRGLOSS; Air Infiltration Glossary (English edition)' Available free-of-charge to participating countries*. Price:£10 to non-participating countries.

5.1 (1983), 5.2 (1984), 5.3(1985), 5.4(1988) Allen, C. 'AIRGLOSS'; Air Infiltration Glossaries (German, French, Italian and Dutch) Supplements.

6 (1981) Allen,C. 'Reporting format for the measurement of air infiltration in buildings' Price:£6 to non-participating countries.

10 (1983) Liddament, M,, Thompson, C. 'Techniques and instrumentation for the measurement of air infiltration in buildings - a brief review and annotated bibliography' Available free-of-charge to participating countries*. Price £15.00 to non-participating countries.

11 (1983) Liddament, M., Allen, C. 'The validation and comparison of mathematical models of air infiltration' Available free-of-charge to participating countries*. Price: £15.00 to non-participating countries.

13 (1984) Allen,C. 'Wind Pressure Data Requirements for Air Infiltration Calculations' Available free-of-charge to participating countries*. Price: £20.00 (price includes copy of TN-13.1) to non-participating countries.

13.1 (1984) '1984 Wind Pressure Workshop Proceedings'. Available free-of-charge to participating countries*. Also available to non-participating countries (see note at TN-13 above).

14 (1984) Thompson, C. 'A Review of Building Airtightness and Ventilation Standards' Lists and summarises airtightness and related standards to achieve energy efficient ventilation. Available free-of-charge to participating countries* only.

16 (1985) Allen,C. 'Leakage Distribution in Buildings' Examines those factors which can influence leakage distribution, including building style, construction quality, materials, ageing, pressure and variations in humidity. Available free-of-charge to participating countries*. Price: £20.00 to non-participating countries.

17 (1985) Parfitt, Y. 'Ventilation Strategy - A Selected Bibliography' Review of literature on choice of ventilation strategy for residential, industrial and other building. Available free-of-charge to participating countries*. Price: £20.00 to non-participating countries.

19 (1986) Charlesworth, P. '1986 Survey of current research into air infiltration and related air quality problems in buildings' Fourth worldwide survey by AIVC containing over 200 replies from 19 countries. Available free-of-charge to participating countries* only.

20 (1987) 'Airborne moisture transfer: New Zealand workshop proceedings and bibliographic review'Available free-of-charge to participating countries* only.

21 (1987) Liddament, M.W. 'A review and bibliography of ventilation effectiveness - definitions, measurement, design and calculation' Reviews definitions of ventilation efficiency and outlines physical concepts, measurement methods and calculation techniques. Available free-of-charge to participating countries* only.

23 (1988) Dubrul,C. 'Inhabitants' behaviour with regard to ventilation. This report summarises the IEA annex VIII study into the behaviour of occupants with regard to ventilation. Price: £15.00 to participating countries, £25.00 to non-participating countries.

24 (1988) 'AIVC Measurment Techniques Workshop: Proceedings and Bibliography' Workshop held at Koge, Denmark in March 1988. Available free-of-charge to participating countries* only.

25 (1989) Blacknell,J. 'A subject analysis of the AIVC's bibliographic database - AIRBASE', 6th edition Comprehensive register of published information on air infiltration and associated subjects. Available free-of-charge to participating countries* only.

26 (1989) Haberda,F and Trepte,L IEA Annex IX 'Minimum ventilation rates and measures for controlling indoor air quality.'Price £15.00 to participating countries, £25.00 to non participating countries.

CONFERENCE PROCEEDINGS

No.1 'Instrumentation and measuring techniques' 1980.

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No.3 'Energy efficient domestic ventilation systems for achieving acceptable indoor air quality' 1982

No.4 'Air infiltration reduction in existing buildings' 1983.

No.5 'The implementation and effectiveness of air infiltration standards in buildings' 1984.

No.6 'Ventilation strategies and measurement techniques' 1985.

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