Air Infiltration Review

a quarterly newsletter from the IEA Air Infiltration and Ventilation Centre

International Energy Agency - AIVC

Vol 20, No 4, September 1999

Edinburgh Hosts a Popular 20th AIVC Annual Conference

by Malcolm Orme, Air Infiltration and Ventilation Centre

This year the 20th Annual AIVC Conference was held between 9th to 13th August, 1999, in conjunction with Indoor Air 99 at the Edinburgh International Convention Centre in Scotland. Indoor Air 99 itself covered all aspects of the indoor environment, with the AIVC sessions concentrating on areas of particular relevance to building ventilation. In particular these were:

- energy,
- guidelines, operation and comfort,
- modelling and simulation,
- systems and strategies,
- air cleaning and filtration,
- natural ventilation, and
- components.

A total of 730 papers and posters were presented at Indoor Air 99, in both plenary and parallel sessions. From these, 140 were presented in the AIVC sessions. A selection of AIVC papers from the Conference are described below.

Plenary Sessions

Two AIVC papers were presented during plenary sessions. The first, presented by Martin Liddament (AIVC, UK) reviewed the purpose of ventilation and the quality of ventilation air. In his presentation, he stated that ventilation is the process by which 'clean' outdoor air is intentionally provided to a space and 'stale' air is removed. In an occupied space, its fundamental purpose is to provide oxygen for metabolism and for the dilution of unavoidable pollutants. However, too often it falls upon ventilation to accomplish tasks for which it is not appropriate. For example, pollutant source control is a better strategy than dilution and removal by additional ventilation. Further-

In this issue

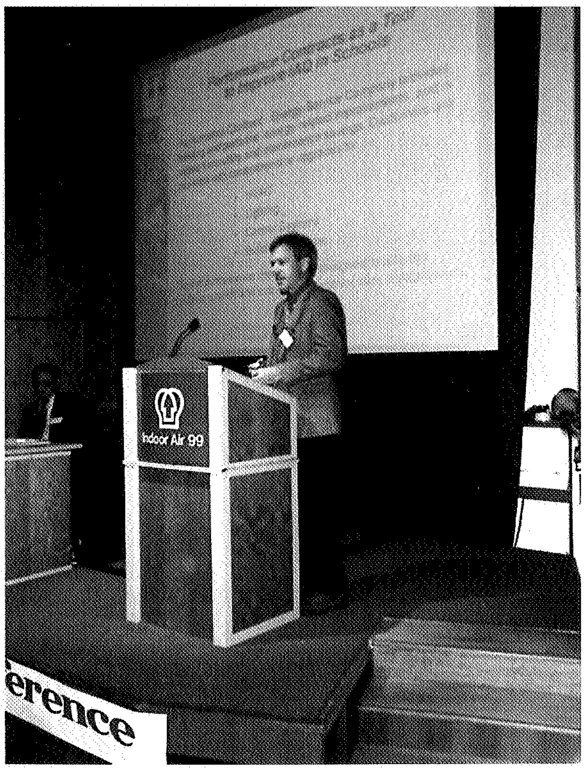
more, the quality of ventilation air may be affected by:

- outdoor air quality,
- the siting of air intakes,
- active control of intake air,
- filtration, and
- cleanliness of the ventilation system.

The second AIVC plenary paper described a survey that has been conducted across 7 European countries. This survey concerned current design methods for ventilation systems in residential and commercial buildings and was part of the EU TIPVENT project. Discussing the results, Åke Blomsterberg (J&W Consulting Engineers, Sweden) indicated that traditional design methods seldom involve advanced calculations. Instead, the preferred methods are simple calculations, rules of thumb, manufacturers' design programs and catalogues and may involve many different handbooks and guidelines. For these reasons, innovative, low energy ventilation systems are seldom introduced.

Selected Papers from the AIVC Sessions

The influence of nocturnal ventilation reduction on daytime indoor air quality has been investigated by Lars Gunnarsen (Danish Building Research Institute, Denmark). (An untrained panel of 45 people assessed the air quality in terms of acceptability.) He suggested two effects may lead to a deterioration of air quality. The first is caused by pollutants being absorbed at night and then re-emitted during the day. The second is due to the slower removal of pollutants at the reduced average ventilation rates. He concluded that if ventilation is stopped for 12 hours every night, then the daytime rate may need to be more than doubled to compensate.



Giorgio Giorgiantoni (ENEA, Italy) has used a detailed description of a typical modern Italian dwelling, with airtightness characteristics determined from blower door tests, to produce a prediction of the IAQ in the dwelling. The ventilation air flows were simulated using the multi-zone model CONTAM96, which was additionally used to calculate the time-dependent concentrations of 3 cooking-generated pollutants. This study represents part of a larger investigation into the characteristics of the Italian dwelling stock in terms of energy use and IAQ (indoor air quality).

In a paper presented on behalf of the authors Mark Bassett and P Gibson, the findings from measurements made in 12 naturally ventilated New Zealand schools were explained. It was found that the wintertime ventilation rates (estimated from changes in carbon dioxide levels over time) were substantially higher than the estimated air infiltration rates alone. However, the average rates were not quite as high as 8 litres per second per person, the value stated in New Zealand Standard NZS 4303 for mechanical systems.

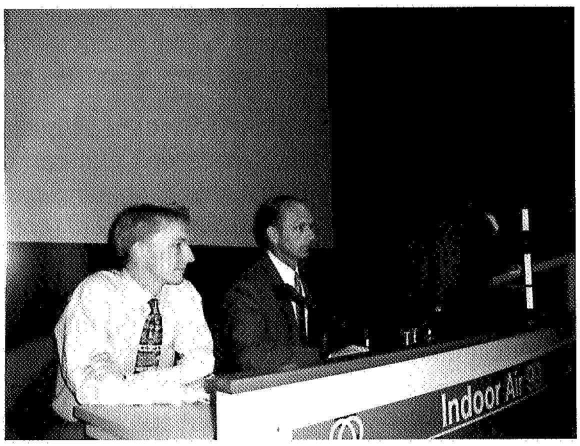
Ultraviolet germicidal irradiation (UVGI) may be used for air disinfection, and therefore to reduce the number of hospital originating infections. This is becoming increasingly critical as the number of drug resistant micro-organisms increases. Clive Beggs (University of Leeds, UK) has undertaken optimisation of a UVGI system in a UK hospital building. He explained how lower air velocities in a system, together with the face area presented to the ultraviolet source, allow greater irradiation doses to be applied to micro-organisms in the air.

Oil is used for corrosion protection for new galvanised sheet metal HVAC components, during storage and transport. However, if this layer remains after installation, it may increase dust accumulation and also serve as a potential growth media for microbes. Pertti Pasanen (University of Kuopio, Finland) gave an account of the development of methods to measure the level of contamination of oil, so that manufacturers are able to check for remaining residues. The 'filter contact' technique was found to give the best recovery of oil from surfaces and the repeatability was good.

In his presentation, Ornulf Kristiansen (NTNU, Norway) explained how an inspection of a representative number of HVAC plants in Trondheim, Norway, has revealed that snow and sometimes rain are easily able to pass through their air intake louvers. This ingress of moisture, which may lead to unwanted microbial growth, was observed in almost all of the systems.

In cold climates, the supply air through vents in mechanical exhaust ventilated buildings may be excessively cold. A way of reducing the draught from such supply vents is to use preheating. In an experimental study of a particular design of supply vent for displacement ventilation incorporating preheating, Elisabeth Mundt (KTH, Sweden) found that for them to operate as intended, a large under-pressure and an airtight building are needed.

Low temperature heating (LTH) systems are those that use, for example, residual, ambient, or renewable sources of heat. Herman Eijdems (Cauberg-Huygen, The Netherlands) discussed the impact of these systems on IAQ, thermal comfort and energy use. He concluded that LTH systems can provide good thermal comfort if they are used in buildings with a high level of insulation and an airtight construction. The IAQ is also positively influenced, with a reduction in dust mites and suspended particles, as well as less stuffiness and odours, because of the lower air temperature.



At the Conference, Klaus Fitzner (Technical University Berlin, Germany) explained his experiments to investigate the influence of air flow patterns in a room on evaporation and humidity distribution around a simulated person. (He has achieved this with a heated wet cylinder to represent a human body.) His work compared the surface temperatures and humidities for mixed and displacement flow. In fact, he demonstrated that the evaporation of water from a heated, wet surface is 20% higher in mixed flow than displacement flow.

The combined control of natural and mechanical ventilation using 'fuzzy' control algorithms was the subject of a contribution by Gordon Sutherland (University of Athens, Greece). In his system, the indoor CO2 level is taken to be the controlled parameter for IAQ. The conflicts between the IAQ control strategy and the control of thermal and visual comfort are resolved through intelligent compensation and adjustment of, e.g. the indoor air velocity and solar control devices.

Best AIVC Paper and Best AIVC Poster

The Best AIVC Paper at the Conference was awarded to Bill Nazaroff (University of California at Berkeley, USA) for his paper, "Particle deposition from turbulent duct flow". In his account of his work, he described a comparison between three theoretical models of particle deposition in rough-walled ducts and also experimental data. He found that all three models predicted particle penetration through an entire ventilation system would be independent of particle size for particle diameters less than 2 micrometers. However, the predicted results between the models differed considerably.

Anne-Marie Bernard (CETIAT, France) won the Best AIVC Poster, for her poster, "Energy loss due to ventilation: impact of average values and simplifications on calculations". In this poster, she explained how simplification of input data for calculations of the energy loss due to ventilation may affect the results. Particularly significant, she determined, are building airtightness, meteorological and site conditions, as well as wind pressure coefficients.

References

The references are to Indoor Air 99 proceedings, volume and page numbers.

Liddament 3,1-6 (AIVC #12421)
Blomsterberg 4, 7-12 (AIVC #12422)
Gunnarsen 1,1-6 (AIVC #12185)
Giorgiantoni 1, 708-713 (AIVC #12216)
Bassett 4, 298-303 (AIVC #12284)
Beggs 2, 659-664 (AIVC #12260)
Pasanen 5, 19-24 (AIVC #12312)
Kristiansen 4, 55-60 (AIVC #12277)
Mundt 5, 45-50 (AIVC #12317)
Eijdems 1, 7-12 (AIVC #12186)
Fitzner 1, 732-737 (AIVC #12220)
Sutherland 1, 367-372 (AIVC #12208)
Nazaroff 2, 24-29 (AIVC #12231)
Bernard 1, 76-77 (AIVC #12198)

Copies of the above papers are available from the AIVC's library.

Air Infiltration and Ventilation Centre

20th Annual Conference

Proceedings

The proceedings of the 20th AIVC Conference, held in Edinburgh, UK, August 1999, will soon be available. The package will include printed abstracts and discussion, and the papers and posters on CD ROM, and will cost £65.00. Please contact the AIVC to place your name on our forward orders list.

AIVC Bookshop – New Publication

Photovoltaics as Part of Building Facade Design: a Synthesis

A report of the European AirLit-PV project, "The Development of a Prototype Facade Unit Integrating Natural Ventilation Daylighting, Solar Protection, Intelligent Control and Photovoltaic Power"
by Martin W Liddament, Oscar Faber Group Ltd, 1999
Available from the AIVC Bookshop, price £20.00 plus postage

The building facade has a pivotal role on the performance of a building in terms of comfort, indoor air quality and energy efficiency. The purpose of AirLit-PV is to develop a cost competitive facade unit that can be integrated into an energy efficient building and which will maximise the benefits of daylighting, shading, local ventilation and thermal insulation. To assist in formulating the design of Airlit-PV, a detailed survey of recent European, case study and other research work has been undertaken. This report presents the results of the survey. Aspects covered include:

- Securing a good indoor climate;
- Dealing with summer overheating;
- Dealing with winter conditions;
- Incorporating photovoltaics;
- Controls;
- Energy benefit;
- Cost Analysis.

A vital part of any new approach is that it should be cost competitive with existing technology and should not have an inferior performance in terms of indoor environmental conditions. Energy saving must also be demonstrated. The AirLit-PV approach to reducing energy use and costs in outlined.

AIVC 21st Annual Conference
First Announcement and Call for Papers

Innovations in Ventilation Technology

Tuesday 26th September - Friday 29th September 2000
Steigenberger Kurhaus Hotel, The Hague, Netherlands

The Air Infiltration and Ventilation Centre's 21st Annual Conference will focus on the latest ideas and concepts for meeting ventilation needs. Papers covering the following topics are invited:

- New developments;
- Integration of ventilation technology with cooling and heating needs;
- Ventilation monitoring and control systems;
- Case studies;
- Quantifying ventilation need;
- New guidelines and requirements;
- New developments in simulation and design;
- Coping with poor outdoor air quality.

Abstracts

Abstracts of proposed papers should be 300 – 500 words in length and submitted by 31st January 2000 to the Conference Secretariat

Selection Process

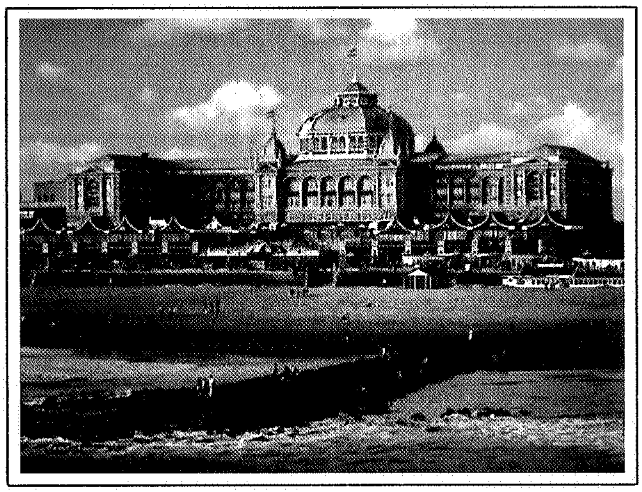
Papers for the conference will be selected on the basis of received abstracts and authors will be notified by 31st March 1999. Completed papers (up to 12 pages in length) will be required by 31st July 1999.

Optional Full (Journal) Peer Review of Papers

Authors may nominate their paper for full peer review to be considered for publication in a special edition of a recognised journal.

Conference Proceedings

All presented papers received in time for publication (31st July 2000) will be published in the conference proceedings.



Conference Format

The conference will take the form of full oral presentations and shorter oral presentations combined with poster displays. All authors will have the opportunity of making an oral presentation in plenary session.

Further Details

The conference will be held over four days and the overall cost will include three nights bed/breakfast, three lunches, conference attendance, proceedings and Gala Dinner. A conference brochure with full details will be circulated shortly.

For further information please contact the Conference Secretariat:

Helen Shawcross, Conference Organiser, Air Infiltration and Ventilation Centre, Sovereign Court, University of Warwick Science Park, Sir William Lyons Road, Coventry CV4 7EZ, UK Tel: +44 (0)24 76 692050, Fax: +44 (0)24 76 416306, email airvent@aivc.org

Our WWW Home Page will keep you updated on the Conference details and other AIVC activities:

http://www.aivc.org/

Visitors to Air Infiltration and Ventilation Centre Library and Bookshop

The AIVC Library holds over 12,500 documents on the subject of air infiltration, ventilation and air quality in buildings, and related topics. The library's bibliographical database, "Airbase", available on CD ROM, can be consulted at the Centre, and visitors are welcome to consult papers and borrow documents. The Centre staff can help with enquiries of a technical nature.

The AIVC bookshop holds copies of all AIVC technical publications, as well as various third party reports of interest to customers.

To arrange a visit, please contact the AIVC to arrange an appointment. The Centre is open Monday to Friday, 08.30 to 17.30 hrs

Determination of Air Change Rates by CO Monitoring of Supply and Exhaust Air Concentrations

By Martin Kraenzmer, Division of Buildings Services Engineering, Chalmers University of Technology, Gothenburg, Sweden

This paper describes a method for determining the air change rate in a room or a building by continuous monitoring of the CO concentration in both supply and exhaust air. By using a mass balance equation, the indoor concentration of CO can be numerically calculated for various air change rates. The value of the air change rate used in the equation that gives the best correlation between measured concentration and calculated concentration provides an estimate of the air change rate for the volume studied.

Introduction

The air change rate, n, can be defined as the ratio of the supplied fresh air flow rate, q, (including infiltration), to the volume, V, n=q/V (1). There are several ways to determine the air change rate for a ventilated room. One way is to measure the supply airflow or the exhaust airflow. The infiltration or exfiltration then has to be estimated. Decay rate measurements with a tracer gas, where the infiltration and exfiltration is included, is another very common method. Tracer gases for air change rate measurements can be sulphur hexafluoride, dinitrogen oxide and carbon dioxide.

Air change rate measurements by comparing indoor and outdoor concentrations of particulate polycyclic aromatic hydrocarbons (particulate PAHs) originating outdoors have been reported (2). One disadvantage when performing measurements with particulate PAHs, is their tendency to stick to charged surfaces and to filters (3) which makes it difficult to distinguish between the amount of particles removed by the ventilation and the amount of particles removed by sinks indoors.

This paper describes a method for determining air change rates by monitoring the concentration of carbon monoxide (CO) in both the supply air and exhaust air. Carbon monoxide is an inert gas and there are usually no sources indoors unless tobacco smoking takes place. From the monitored supply air concentration of carbon monoxide an exhaust air concentration can be numerically calculated for various air change rates and then compared to the monitored exhaust air concentration. The air change rate used in the calculation which gives the best correlation between the calculated and monitored exhaust air concentration provides an estimate of the air change rate for the room or building studied. The method described has been applied in a test chamber where the air change rate obtained by this method has been compared to air change rate simultaneously measured with a traditional method.

Modelling and Monitoring

A mass balance equation for calculation of the indoor carbon monoxide concentration is needed to determine the air change rate with the method described. What is supplied to the volume in question is equal to what is removed from, and stored in, the same volume. Equation (1) is a mass balance equation and it is valid when the air is assumed to be well mixed, which is often the case in many buildings (4). Equation (2) is the analytical solution to equation (1) adjusted to handle numerical calculations.

$$\dot{V} \cdot C_S + \dot{V}_{source} = \dot{V} \cdot C_E + \dot{V}_{sink} + V \cdot \frac{dC_E}{dt} \tag{1}$$

$$C_E^{n+1} = C_S + \frac{\dot{V}_{source} - \dot{V}_{sink}}{\dot{V}} + \left(C_E^n - \frac{\dot{V}_{source} - \dot{V}_{sink}}{\dot{V}} - C_S \right) \cdot e^{-\frac{\dot{V}}{V}\Delta t} \tag{2}$$

where:

$\dot{V}_{source}$	internal source strength	cm^3/s
$\dot{V}_{sink}$	internal sink effect	cm^3/s
$\dot{V}$	airflow rate	m^3/s
V	volume	m^3
C_S	supply air concentration	ppm
C_E	exhaust air concentration	ppm
C_E^{n+1}	exhaust air concentration at the beginning of the next time interval	ppm
C_E^n	exhaust air concentration at the beginning of the current time interval	ppm
C_S	average supply air concentration during the current time interval	ppm
Δt	time step	s

(ppm = volumetric parts per million)

Equation (2) is more often presented with outdoor and indoor concentrations instead of the supply and exhaust air concentrations (5). The air is assumed to be well mixed which makes the exhaust air concentration equal to the indoor air concentration. Instead of using the outdoor concentration, the supply air concentration is used since it could be somewhat different from the outdoor concentration measured near the building, depending on where the outdoor air intake is located. When modelling indoor carbon monoxide concentrations, the sink and source terms can often be neglected.

The calculation of the exhaust air concentration has to be numerical in order to handle variations in the supply air concentration. The concentration values measured in the supply air are inserted in equation (2) together with various air change rates. The calculated concentration values for the exhaust air are compared with the measured concentration values for the exhaust air. The monitoring should be carried out over a time period of a few hours and sampling could, for example, be every 10 minutes.

Using this method with carbon monoxide requires a distinct variation in the concentration during the monitoring period and consequently, this method is better suited for urban areas and other areas with high traffic intensity or areas where there is a combustion plant close by. The variations should be large also in comparison to the electronic noise from the measurement equipment.

Experimental Procedure

Measurements were carried out in a test chamber in order to demonstrate how air change rates can be determined by the method described in this paper. Continuous measurements of carbon monoxide were carried out using a PAS instrument (photoacoustic spectroscopy), Brüel & Kjær type 1302, with a multipoint sampler unit.

The test chamber has a volume of 19.3 m3 and is located at Chalmers University of Technology in Göteborg, Sweden, 100 m from a street with high traffic intensity. The exhaust airflow can be measured as a pressure difference over a flange in the exhaust air duct. The ventilation system is designed to give a 10 Pa higher pressure in the chamber and the leakage from the chamber is a function of this pressure. The measured exhaust airflow together with the leakage airflow produced an air change rate that was 0.5±0.1 h-1 during the measurement period. Using a manifold system the concentration of carbon monoxide was monitored in the supply air duct and in the exhaust air duct.

Results

Figure (1) shows the measured concentration in the test chamber of carbon monoxide in the supply air and in the exhaust air over time.

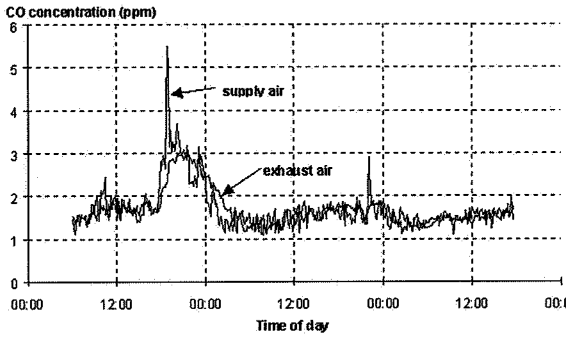


Figure 1: The carbon monoxide concentration in the supply air and in the exhaust air measured in a test chamber over time.

For various air change rates, the exhaust air concentration was calculated with equation (2) and the measured supply air concentration values. By an interpolation calculation the calculated exhaust air concentration values were determined at the same moment as the measured exhaust air concentration values were sampled to enable a correlation calculation. Figure (2) shows the correlation between the measured exhaust air concentration values and the calculated exhaust air concentration values for various air change rates.

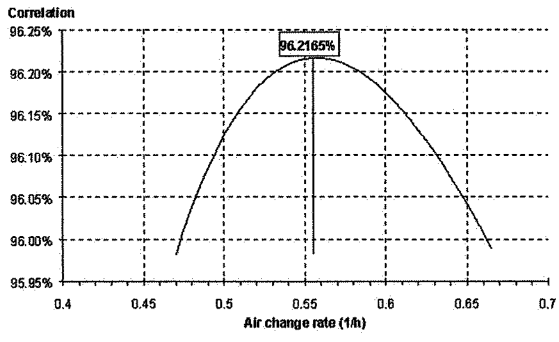


Figure 2: The correlation coefficients between measured exhaust air concentration values and calculated exhaust air concentration values of carbon monoxide for various air change rates in a test chamber.

The highest correlation coefficient, the maximum value in figure (2), is achieved when the air change rate used in the calculation is 0.55 h-1. Thus, according to this method the air change rate for the test chamber was 0.55 h-1 during the measurement period. In figure (3) the calculated exhaust air concentration is shown together with the measured exhaust air concentration as a function of time. The fast but small variations in concentration in the measured values in figure (3) are mainly caused by the measuring equipment noise.

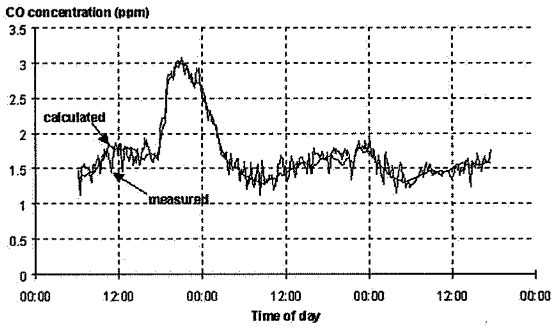


Figure 3: The measured concentration and the calculated concentration of carbon monoxide in the exhaust air in a test chamber as a function of time. The calculated concentrations were achieved using an air change rate of 0.55 h^{-1}.

Conclusions

Several advantages can be gained by employing the method described to measure the air change rate in a room or building by monitoring carbon monoxide concentrations, or the concentrations of other gases in the outdoor air which show fast temporary variations. However, this method requires a variation in the exhaust air concentration of carbon monoxide that is larger than the electronic noise from the measuring equipment. In urban areas in Göteborg, for instance, the concentrations of carbon monoxide may often be of the same magnitude as the ones presented in this paper. Even though the variations of the concentrations are not large, the results show that the method is applicable for determination of air change rates. In an area with higher concentrations of carbon monoxide in the outdoor air, for example in Nottingham (6), the method would be ideal.

Acknowledgements

This study was supported by the Swedish Council for Building Research. The author wishes to thank Professor Ove Strindehag and Dr. Lars Ekberg at Chalmers University of Technology, Göteborg for all their helpful comments and suggestions.

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Air Infiltration Review

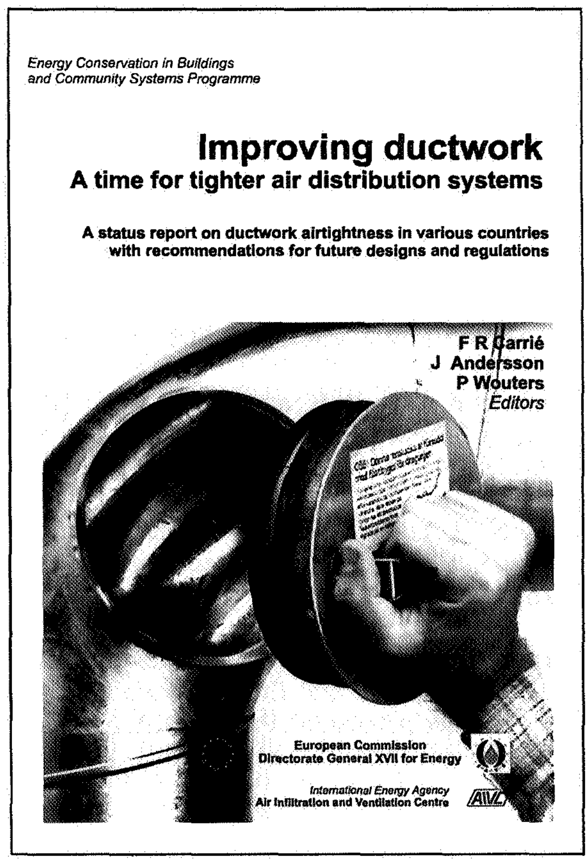
Editor: Janet Blacknell

Air Infiltration Review has a quarterly circulation of 3,500 copies and is currently distributed to organisations in 40 countries. Short articles or correspondence of a general technical nature related to the subject of air infiltration and ventilation are welcome for possible inclusion in AIR. Articles intended for publication must be written in English and should not exceed 1,500 words in length. If you wish to contribute to AIR, please contact the Air Infiltration and Ventilation Centre. Please note that all submitted papers should use SI units.

AIVC Bookshop - New Publication

Improving Ductwork – A Time for Tighter Air Distribution Systems

edited by F R Carrie, J Andersson, P Wouters



A large number of modern European buildings are equipped with ducted air distribution systems. Because they represent a key parameter for achieving a good indoor climate, increased attention has been given to their performance during the past fifty years. One aspect that is particularly developed in this handbook concerns the airtightness of the ductwork, which has been identified as a major source of inadequate functioning and energy wastage of HVAC systems.

The investigations were carried out within the framework of the DUCT project (1997-1998) whose objectives were to quantify duct leakage impacts; identify and analyse ductwork deficiencies; propose and quantify improvements; and propose modifications to existing standards.

The handbook includes expert knowledge derived from research and industry, as well as practical information based on surveys and field work. Calculation details are condensed to put the emphasis on end results and qualitative information.

It is estimated that space heating represents about a quarter of the final energy demand in the EU. In addition, climate control is strongly related to public health and productivity concerns and recent studies suggest that it has an effect on measures of productivity such as absence from work or health costs. These usually lie between 5% and 15%.

In this context, the efficiency of air distribution systems is a very active field of investigation. These systems are often used in modern European buildings as a strategy to control thermal conditions and indoor air quality. Many problems have been reported in relation to energy use and peak power demand, clean air supply, flow balancing and airtightness etc. The purpose of this handbook is to give an overview of these aspects with a special focus on duct leakage and its consequences.

In the context of energy conservation, sustainable development, and harmonisation of standards and regulations in Europe, this issue needs to be re-addressed to evaluate the implications of a tight air duct policy at the European level.

The publication is available from the AIVC Bookshop, price £35.00 for customers in EU and AIVC, £45.00 for others, and £20.00 for bulk orders of more than 10 items.

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Air Infiltration Review. Quarterly newsletter containing topical and informative articles on air infiltration research and application. (AIR)

Recent Additions to AIRBASE. Quarterly bulletin of abstracts added to AIRBASE, AIVC's bibliographic database.(RA)

AIRBASE

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WORLD WIDE WEB

The AIVC's home page holds Air Infiltration Review, publications and conference details and a list of papers based on the current edition of Recent Additions. The address is http://www.aivc.org/

GUIDES

Guide to Energy Efficient Ventilation, Liddament M W, 1996 (GV)

Air Infiltration Calculation Techniques: an Applications Guide, 1986, (CT)

Air infiltration control in housing: Handbook, 1983 (HNBK)

TECHNICAL NOTES

(Code TN)

11. Validation and comparison of mathematical models, 1983
13. Wind pressure data requirements, 1984
13.1 Wind Pressure Workshop Proceedings, 1984
16. Leakage Distribution in Buildings, 1985
17. Ventilation Strategy - A Selected Bibliography, 1985
20. Airborne moisture transfer: workshop proceedings, 1987
21. Review and bibliography of ventilation effectiveness, 1987
23. Inhabitants' behaviour with regard to ventilation, 1988
24. AIVC Measurement Techniques Workshop, 1988
26. Minimum ventilation rates, IEA Annex IX 1989
27. Infiltration and leakage paths in single family houses, 1990
28. A guide to air change efficiency, 1990
28.2A guide to contaminant removal effectiveness, 1991
32. Reporting guidelines for airflows in buildings, 1991
33. A review of building air flow simulation, 1991
34. Air flow patterns: measurement techniques., 1991
35. Advanced ventilation systems, 1992
36. Airgloss Air Infiltration Glossary, Limb M J, 1992
37. A Strategy for Future Ventilation Research and Applications, Liddament M W, 1992
39. A Review of Ventilation Efficiency, Liddament M W, 1993
40. An Overview of Combined Modelling of Heat Transport and Air Movement, Kendrick J F, 1993
41. Infiltration Data from the Alberta Home Heating Research Facility, Wilson D and Walker I, 1993
42. Current Ventilation and Air Conditioning Systems and Strategies, Limb M J, 1994
43. Ventilation and Building Airtightness: an International Comparison of Standards, Codes of Practice and Regulations, Limb M J, 1994
44. Numerical Data for Air Infiltration and Natural Ventilation Calculations, Orme M S, 1994
45. Air-to-Air Heat Recovery in Ventilation, Irving S, 1994
46. 1994 Survey of Current Research, Limb M J, 1995
47. Energy Requirements for Conditioning of Ventilation Air, Colliver D, 1995

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Air Infiltration Calculation Techniques (CT: Participants - £15.00, Non Participants - £22.50
Air Infiltration Control in Housing (HNBK): Participants - £15.00, Non Participants - £22.50
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48. The Role of Ventilation in Cooling Non-Domestic Buildings, Irving S J, 1997
49. Energy Impact of Ventilation: Estimates for the Service and Residential Sectors, Orme M S, 1998
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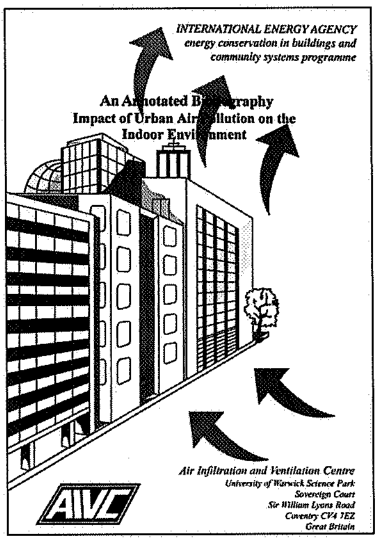

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Aim to review and technically assess current literature and provide a concise but in depth overview of a variety of subjects. (Code BIB)

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7. Ventilation and Acoustics in Buildings, 1997
8. Passive Cooling Technology for Office Buildings in Hot Dry and Temperate Climates, 1998
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AIVC CONFERENCE PROCEEDINGS

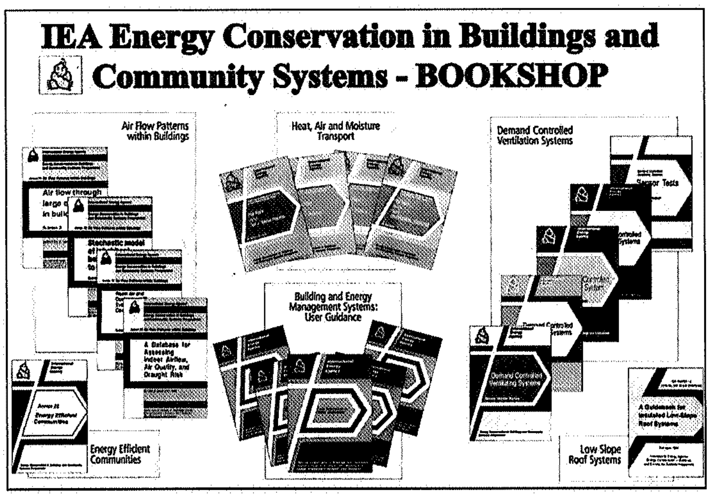
Papers from earlier AIVC Conference Proceedings are also available. Contents pages can be forwarded on request. (Code CP)

11. 'Ventilation System Performance' Belgirate, Italy, 1990
12. 'Air Movement and Ventilation Control within Buildings', Ottawa, Canada, 1991, 3 volumes
13. 'Ventilation for Energy Efficiency and Optimum Indoor Air Quality', France, 1992
14. 'Energy Impact of Air Infiltration and Ventilation', Denmark, 1993
15. 'The Role of Ventilation', Buxton, UK, 1994
16. 'Implementing the Results of Ventilation Research', Palm Springs, USA, 1995
17. 'Optimum Ventilation and Air Flow Control in Buildings', Gothenburg, Sweden, 1996
18. 'Ventilation and Cooling', Athens, Greece, 1997
19. 'Ventilation Technologies in Urban Areas', Oslo, Norway, 1998

LITERATURE LISTS

Literature lists are searches carried out on the AIVC's bibliographical database, "Airbase". They are an up-to-date selection of material, usually between 30-40 abstracts, which provide a useful introduction to the relevant subject area. Papers listed are available from AIVC library. Contact AIVC for full list. (Code LL)

20. Computational fluid dynamics
21. Displacement ventilation
22. Moisture and condensation
23. Sustainability
24. Passive cooling
25. Passive solar design
26. Effects of outdoor air pollution on indoor air
27. Kitchen ventilation
28. Crawlspaces
29. Design for fire/smoke movement
30. Use of vegetation to clean indoor air



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Forthcoming Conferences

ESS99
11th European Simulation Symposium and Exhibition Simulation in Industry
26-28 October 1999
Erlangen, Germany
Philippe Geril, SCS International, University of Ghent, Coupure Links 653, B-9000 Ghent, Belgium, Fax: +32 9 223 4941, email Philippe.Geril@rug.ac.be
The scientific programme covers the following topics: simulation methodologies and tools, simulation in logistics, simulation in virtual reality, analytical and numerical modeling techniques, simulation in industry/economics, simulation in telecommunications, high-performance simulation. The keynote lecture will be on numerical simulation of large scale problems from science and engineering.

ASTM Symposium on Air Quality and Comfort in Airliner Cabins
October 27-28, 1999
New Orleans, USA
Dr Niren L Nagda, ENERGEN Consulting, Inc., 1990 Wild Cherry Lane, Germantown, MD 20874, USA, Tel: 301 540 1300, Fax: 301 540 6924, email nnagda@paltech.com

Building Ventilation Design: to seal or not to seal!
28 October 1999
Institute of Mechanical Engineers, London, UK
Tina Churcher S687, 1 Birdcage Walk, London SW1H 9JJ, UK, Tel: +44 171 973 1258, Fax: +44 171 233 1654, email: t_churcher@imeche.org.uk

International Symposium on Occupational Exposure Databases and Their Application for the Next Millennium
1-3 November 1999
The Forum Hotel, London, UK
ACGIH, PO Box 691536, Cincinnati, OH 45269-1536, USA, Tel: +1 513 742 2020, Fax: +1 513 742 3355, email oedb@acgih.org, http://ww/acgih.org/events/oedb99.htm

International Symposium on Occupational Health for Europeans
3-5 November 1999
Helsinki, Finland
Occupational Health for Europeans '99, Finnish Institute of Occupational Health, Ella Hanninen, Topeliuksenkatu 41a A, FIN-00250, Helsinki, Finland, Tel: +358 9 4747 546, Fax: +358 9 2413 804, email ella.hanninen@occuphealth.fi, http://www.occuphealth.fi/eng/project/oh99

ISHVAC '99
The 3rd International Symposium on HVAC
17-19 November 1999
Shenzhen, China
Submissions from America, Japan, Taiwan, or Mainland China: Secretariat - ISHVAC '99, Department of Thermal Engineering, Tsinghua University, Beijing 100084, China, Fax: 86 10 6277 0544, email jydte@mail.tsinhua.edu.cn
Submissions from all other regions: Secretariat - ISHVAC '99, Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong SAR, China, Fax: (852) 2774 6146, email Bebetang@polyu.edu.hk
WWW-Home Page www.ishvac.com

Sharing Knowledge of Sustainable Buildings
16-17 December 1999
Bari, Italy
Nico Maiellaro, IRIS-CNR, SKSB Conference Secretariat, Strada Crocifisso 2/B, 70125 Bari, Italy, Fax: + 39 0805482533, email iris@area.ba.cnr.it, Conference Web Site http://www.iris.ba.cnr.it/SKSB

Ventilation 2000
6th International Symposium on Ventilation for Contaminant Control
4-7 June 2000
Helsinki, Finland
Secretariat, Ventilation 2000, Finnish Institute of Occupational Health, Solveig Borg, Topeliuksenkatu 41 a A, FIN-00250 Helsinki, Finland, Tel: +358 9 4747 900, Fax: +358 9 2413 804, email solveig.borg@occuphealth.fi, http://www.occuphealth.fi/eng/project/vent2000

Renewables: the Energy for the 21 Century.
World Renewable Energy Congress - VI
WREC 2000
1-7 July 2000
Metropole Hotel, Brighton, United Kingdom
Professor Ali Sayigh, Congress Chairman and Director General of WREN, 147 Hilmanton, Lower Earley, Reading RG6 4HN, UK, Tel: +44 1189 611364, Fax: +44 1189 611365, email: asayigh@netcomuk.co.uk, http://www.WRENUK.CO.UK
Topics are: policy issues; low energy architecture: LEA; Photovoltaic technology; solar thermal applications; wind energy generation; biomass conversion; related topics; solar energy materials; geothermal applications.

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