Air Infiltration Review

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International Energy Agency - AIVC

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Ventilation Standards

by Peter J Jackman,
The Building Services Research and Information Association, Bracknell, UK

The development of international standards is generally more like a marathon than a sprint. Nevertheless, significant progress on ventilation standards has been made in recent years, particularly in CEN (European Committee for Standardisation).

Established in 1989, CEN TC 156 "Ventilation for buildings" has been working to produce standards and other reference documents for ventilation products and systems, and for the terminology used to describe them. This work was divided between nine Working Groups, each with input from a mix of European countries. In addition, representatives of TC 156 are participating in a joint working group (involving TC 89 and 228 as well) to produce information on calculation procedures for determining temperatures, heating and cooling loads, and energy consumption in buildings.

The first publication was a CEN Technical Report on Terminology (CR 12792). It was produced as an interim document to encourage the use of common definitions in the standards being developed while realising that a final, definitive publication could not be prepared until most, if not all, of the standards on ventilation had been drafted.

In relation to products, the most rapid progress has been made on ductwork standards. Dimensional standards have been published on:

- rectangular sheet metal ducts - EN 1505
- circular sheet metal ducts - EN 1506
- circular flanges for ventilation ductwork - EN 12220

In addition a European Pre-standard was published in 1997 on the requirements for ductwork components to facilitate the maintenance of ventilation systems (ENV 12097). Other ductwork standards are in progress.

Other ventilation products for which standards have been published are dampers and valves (aerodynamic testing – EN 1751), and air handling units (mechanical performance – EN 1886).

There are many other drafts in the pipeline (or should it be "ducting") covering the performance testing of such products as air terminal devices, constant and variable rate terminal units, louvres, chilled ceilings and beams, and air handling units. There is a distinct

In this issue

1752. It specifies the levels of temperature, air velocity, noise, and ventilation for occupied spaces. Values are given for three categories of environmental quality: A – a high level of expectation, B – a medium level and C – a moderate level. Supporting information is given on the derivations of the specified values of the parameters as well as to enable alternatives, such as different clothing levels, to be accommodated in the design assumptions.

Practical examples of the derivation of appropriate criteria are also included.

The most debatable section is on indoor air quality. Here, prominence is given to the evaluation of the required ventilation rate for comfort based on perceived air quality, the method developed by Professor Fanger and his colleagues in Denmark. While some data is presented, it is acknowledged that more research is needed to provide reliable information on pollution loads from materials and on the additive effects of emissions from multiple sources.

Nearing completion is a standard on the test procedures and methods of measurement for application at the hand-over stage of a completed system installation. It covers checks on the completeness of the system, verification of its operational capability and functional measurements to determine whether or not the system achieves the performance expected.

Over 40 publications are included in the work programme of TC 156 so there are still quite a number under development. For further information contact your national standards body in Europe or the Secretariat, Graham Edwards, BSI, 389 Chiswick High Road, London W4 4AL, Tel: +44 181 996 9000, email: graham_edwards@bsi.org.uk

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.

New Contact Numbers for the Air Infiltration and Ventilation Centre

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Low Air Infiltration is Necessary but Insufficient

by Geoffrey Brundrett

Buildings lose most of their energy in one of two ways. The first is heat conducted through the building fabric. Traditionally this was the dominant loss. Calculations can be undertaken with some precision. The growing use of thermal insulation has reduced this heat loss dramatically. The other heat loss is through ventilation. There are two components to this ventilation loss. The first is the designer's planned air flow to provide sufficient dilution of the likely pollutants inside the building to make the building healthy and comfortable. This energy loss is now comparable in magnitude to the fabric loss. The second is the casual air infiltration which results from defects in the structure and the effect of the wind and outdoor temperature on them. The likely air quantity through infiltration is unknown at the design stage for many buildings. New prefabrication and other construction techniques are introducing even more variation into the air tightness of buildings and there is a suspicion that infiltration rates are increasing in many newer constructions. The actual air flow rate due to infiltration depends upon the number, size and location of the defects and the vagaries of the weather around the building, particularly wind speed. (Liddament 1988, ASHRAE 1997). The magnitude of this random loss varies widely from building to building depending upon the construction company and the building design details. (Potter et al 1995). In many buildings it can be a significant part of the total heat loss.

The campaign, driven by energy conservation and supported world wide over the last twenty years, has been for those countries which require heating or air conditioning to build low infiltration buildings. (AIVC 1981, Limb 1994, Perera 1994). Countries with harsh winter climates, such as Scandinavia and North America, know that low infiltration is necessary for the survival of their structures. Infiltration can undermine the thermal insulation, can lead to interstitial damp and rot and even the creation of destructive ice boils within the facade. New design ideas, such as introducing an air barrier and selecting sealants with care, have been translated slowly from the colder countries to the temperate ones. New thinking, which involves performance criteria in the building specification and their subsequent testing of completed building, is now spreading. In terms of low air leakage this is usually achieved by means of a pressure test. External fans are incorporated into the door or window and the building is pressurised and depressurised from 10 Pa to 75 Pa or more pressure above and below atmospheric. (CGSB 1986, ASTM 1987, 1988, ASHRAE 1988, Perera et al 1989, Naamm, 1993, Limb 1994, Potter 1998). The air flow through the building at these pressures is used as an index of air tightness. The index is not directly linked to air infiltration rates. In Britain such performance testing is used routinely by the knowledgeable building purchaser. Such purchasers tend to be associated with supermarkets or developers who retain ownership of their building and make a business out of renting. The supermarkets found that low frost build up on the frozen foods and easy draught free access to the store were as welcome as the real benefit of energy savings. In offices the energy savings were reinforced by less staff complaints of discomfort.

Imaginative public discussion instigated by the UK Department of Environment Transport and the Regions last sought ideas to help Britain lower the energy use of buildings. Two main ideas emerged. The first was a move towards a performance based specification of an air tight building envelope, which would minimise the energy waste through excess infiltration. This would mean pressure testing new buildings. The second even more profound wish was for existing buildings to come under the new regulations whenever the building changed ownership or use.

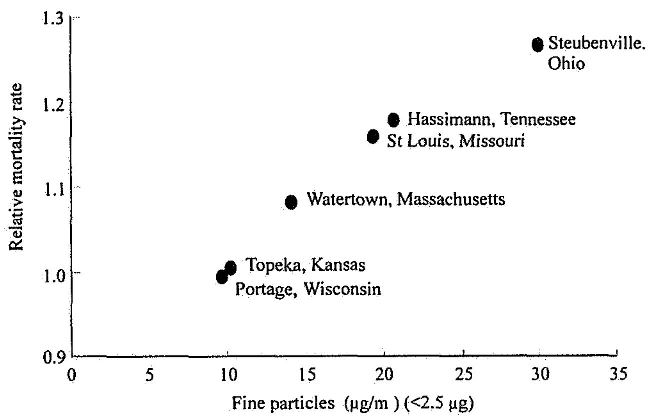
However low infiltration buildings do have important implications for designers. These fall into five categories:-

1. Future ventilation will come in through the planned route. Much is known about the odour emitted from cigarette smoke and body odours but the research on the importance of odours from plastics, sealants, plasticisers, mastics in the fittings and furnishings of the building has not yet reached some national guidelines. Research has also shown the importance of clean ductwork if smells are to be avoided. (Fanger et al. 1988, ASHRAE 1989).

2. The location of the building air inlet is critical. Once the air comes in through one point then the air quality entering the building depends completely on the location of that air inlet. It must be away from car exhaust and out of the plume track of neighbouring ventilation exhausts and chimneys. (Kukadia 1997, Irving 1999). Wind tunnel modelling is recommended for city centre sites.

3. Is the incoming air sufficiently clean? Filters are traditionally fitted to mechanical ventilation systems and to air conditioning plants. These are designed to keep the equipment clean. Recent epidemiological studies are consistently showing the ill health effects from exposure to city dust. Any reduction in dust burden will have a pronounced benefit to health. The relationship is shown is Figure 1 (Dockery et al 1993, Holdgate et al, 1998). Even a modest reduction in dust concentration is worth while. We do spend most of our time inside buildings.

4. We must provide adequate access for duct cleaning. Countries such as Sweden have compulsory duct cleaning and now have a



(Source: Dockery et al 1993)

Figure 1

compulsory inspection of all mechanical ventilation systems, even domestic ones, along the lines of our testing for car safety but at less frequent intervals. Preliminary results from the Swedish experience suggests that even for such a health conscious country the ventilation systems in place have not received the maintenance attention they deserved. Recent recommendation for Britain proposed an annual cleaning of ductwork but the simple observation of public buildings shows that the guidelines are not yet well understood (HSE 1992, HVCA 1998).

5. Moisture control improves occupant satisfaction. Large scale research studies show around a third of office staff are not satisfied with their office ventilation. New research suggests that freshness of the indoor air has much to do with its temperature and moisture content, low temperatures and low humidities being preferred. Once we achieve our safe and healthy buildings we can move on the higher levels of occupant satisfaction through closer moisture control (Fang et al 1996).

The final question is one of professional responsibility. Engineers usually deal with plant and equipment and many find it difficult to accept customer satisfaction and health issues as part of their responsibility for the human factors. ASHRAE members vote on the issue in June this year, to decide if they do have such responsibility. Other countries are watching.

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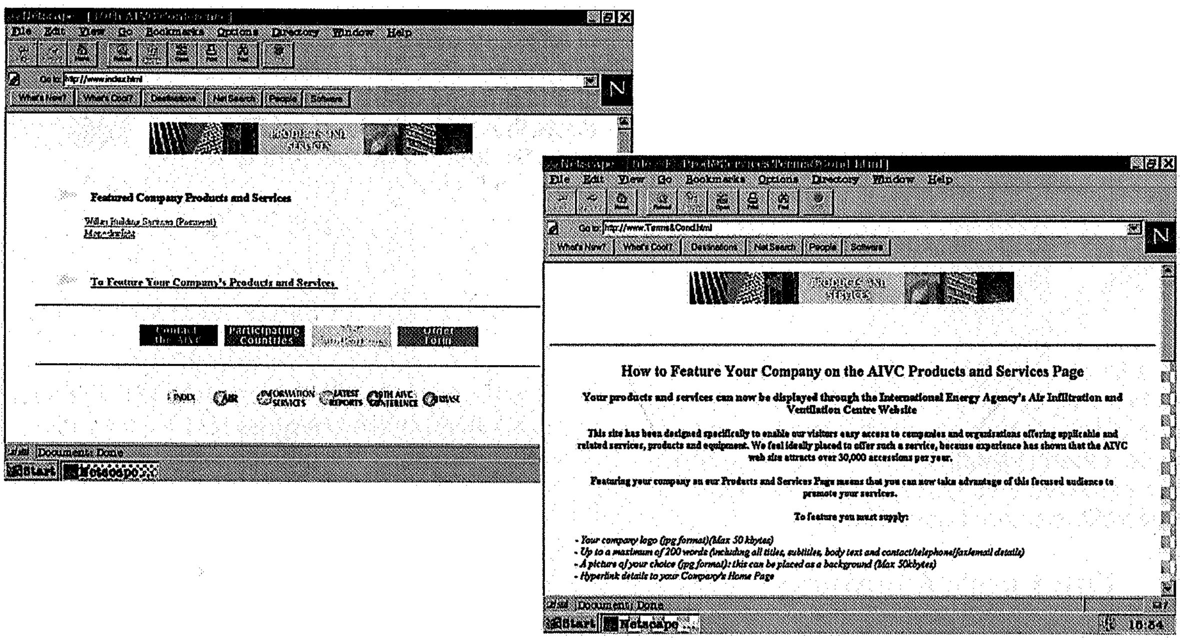

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ISH Trade Fair 1999

The ISH International Trade Fair for House and Building Technology attracts a large number of visitors and exhibitors each year. In fact, this year over 220,000 visitors from 120 countries attended the fair, which took place between the 23rd to 27th March, 1999, at the Messe Frankfurt, located in Frankfurt am Main, Germany. The sections concerning air conditioning and ventilation technologies displayed a vast range of products and services, filling three exhibition halls! Examples of just a few of the exhibiting companies and their products are given below.

Heat Recovery

A combined heat recovery heat exchanger and ventilation unit has been produced, which can recover heat with up to 99% temperature efficiency. This unit, manufactured by Paul, is illustrated in Figure 1. Furthermore, a heat recovery wheel, made by Rototherm and suitable for use in large buildings, was demonstrated at the Trade Fair. It allows the recovery of both sensible and latent heat throughout the year, with up to 90% efficiency.

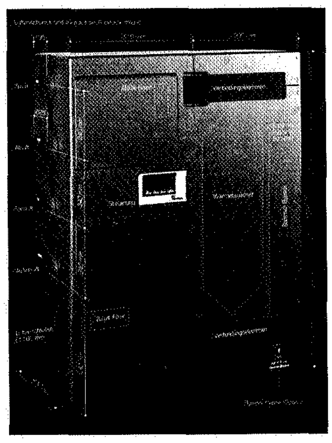


Figure 1

Filtration

Among the filtration equipment producers present at the exhibition was Luftfilter, whose display contained their range of metal filters, suited for applications in, for example, catering facilities. Also, Atex-Filter exhibited their glass, synthetic, natural fibre and microfibre paper based filters.

Ductwork Cleaning

Dura Corporation presented their solution to the problem of ductwork cleaning. Their system relies on a remote controlled robot, mounted with a video camera for inspection, as well as cleaning brushes, and is shown in Figure 2

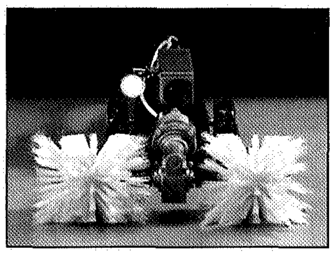


Figure 2

Air Flow Regulators

Aldes Lufttechnik demonstrated their constant volume air flow regulators, of which an example is given in Figure 3 They are designed for use in conjunction with an exhaust ventilation system, as either in-line or terminal devices. The flow in them is regulated by means of silicone diaphragms.

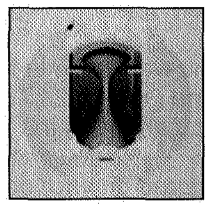


Figure 3

Fire Resistant Ductwork

If a fire starts in a building, it is important that the ventilation system does not contribute to the spread of either smoke or the fire itself. For this reason, Conit has produced a range of fire resistant ducts that can withstand a 120 minute fire test. The duct material is shown in Figure 4.

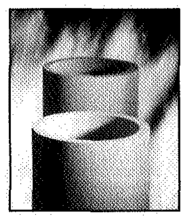


Figure 4

FGK

The Fachinstitut Gebäude-Klima e.V. (FGK) represents the AIVC in Germany. At ISH '99 they displayed guidance on the general principles of operation of both central and decentralised air handling systems for single and multi-family dwellings, together with typical cost data. These included systems with heat recovery, and systems that integrate heating, ventilation, shading, and lighting with sensors for temperature and external conditions. Also described in their displays were case study examples of the modernisation of the building technology in an administration building, a media centre, a historic castle and a district hospital.

Light + Building

Hans Leydecker, President of the Federal Association of the German Heating Industry, commented that, "Recent and future innovations in, for instance heating technology, solar energy and integrated building technology were the dominant subjects at ISH '99." The prevalence of the system concept was an opinion shared by Günther Mertz, Managing Director of FGK, who suggested that the founding of the new exhibition, *Light + Building*, is therefore a highly promising and logical step. *Light + Building* has been scheduled to take place at the same venue between 19th to 23rd March, 2000 and will cover lighting, electrical and air-conditioning technologies.

Additional information about any of the above items may be obtained from Malcolm Orme at the AIVC.

Announcing AIVC Technical Note 51

Applicable Models for Air Infiltration and Ventilation Calculations

by Malcolm Orme

Ventilation modelling may be desirable for:

- *pre-construction evaluation,*
- *prediction of indoor climate,*
- *energy efficient conditioning and ventilation design, or*
- *validation of design.*

Recently, the 'usability' of many ventilation and air infiltration models has improved dramatically. Both simplified and more complex tools have benefited from the development of well-designed user interfaces. In addition, evaluation exercises have further added to the confidence that may be placed in them.

A new AIVC Technical Note, "Applicable Ventilation Models for Air Infiltration and Ventilation Calculations", is now available. It identifies possible areas of application for 15 ventilation and air infiltration models and discusses the input data that must be provided in order to use them. The 66 page report includes 61 references and contains the following sections:

- *Introduction*
- *Building-related Input Data*
  - airtightness data
  - wind pressure coefficients
- *Meteorological Data*
- *Additional Data Considerations*
- *Descriptions of the Models*
- *Example Applications*
- *Evaluation Exercises*
- *Complementary Modelling Techniques*
- *Conclusions*
- *References*

In addition, appendices cover:

- *Contact Information for Obtaining the Ventilation Models*
- *Air Leakage Characteristics of Building Components*
- *Wind Pressure Coefficient Data*

In general, applications for ventilation models include assessing air change rates, fresh air flow rates (infiltration and designed), flow rates between different parts of a building, and exhaust flow rates (exfiltration and designed). Also, therefore, indoor air quality and the effectiveness of ventilation in diluting and removing pollutants can be evaluated. Some models allow personal exposure to pollutants to be evaluated. A further application is the calculation of energy use due to air change. The report concludes that the ease with which predictions may be obtained from ventilation models largely depends on the detail of input data required to configure them. Generally, to realise more detailed results requires the use of a more complex model.

Technical Note 51 may be purchased from the AIVC, priced £20.00

New AIVC Publications

An Annotated Bibliography: Impact of Urban Air Pollution on the Indoor Environment

by Mark Limb, AIVC
Available from the AIVC, Price £15.00 (Participants only)

Aims to identify and introduce the most significant areas of concern in relation to the wide-ranging subject area.

Top Down Ventilation and Cooling in Urban Areas

Symposium 15th April 1999 – Proceedings

Report of DETR Partners in Technology Research Project 39/3/413, Stack Ventilation and Cooling for Urban Sites

Bartlett School of Architecture, Building, Environmental Design and Planning, Faculty of the Built Environment

Available from the AIVC Bookshop, price £24.00

Summary

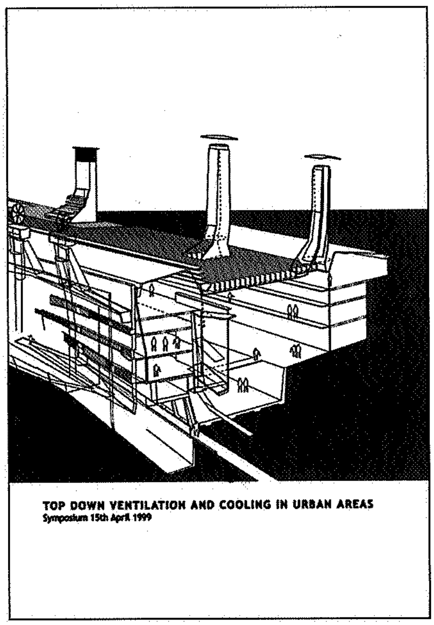
For various reasons, ventilation engineers are advised to take air into buildings from roof level in urban areas. This has, up to now, required the use of fan driven ducted ventilation systems. Fan driven ventilation systems require a continuous supply of electrical energy in order to operate. Fans generate noise and some concerns have been raised that this noise itself contributes to Sick Building Syndrome.

There is, in parallel, a considerable amount of worldwide research into methods of ventilating buildings without the use of fans, both to provide air for occupants and to use the airflow at night to cool the building structure. There are now some very successful examples of buildings that are ventilated and cooled in this way. Extensive "take up" of this type of technology will reduce dependence of electrical power generation.

This report is targeted at informed clients, their architects, engineers and manufacturers, government agencies and researchers in the field. It describes a series of experiments with a common aim, to seek ways of taking air in and out of buildings from the top without the use of fans, so that the resulting buildings are largely or totally passively ventilated and cooled. The report is not a design guide. It offers a concept to the construction industry as a whole for discussion and further evaluation.

The research that has been undertaken indicates that intake air must be actively cooled when the internal air temperature is below the external air temperature in order to provide ventilation on hot summer days. This temperature difference can be as much a 9 Deg. C. Large scale experiments have demonstrated that it is possible to achieve this using gravity down-draught coolers that offer very little resistance to airflow in other conditions. Further experiments have shown that it is possible to ensure that wind pressures on intake and extract terminals will assist ventilation airflow rather than oppose it. These experiments and their implications are described in this report. A common description of the efficiency of complete ventilation systems is given.

The introduction of a small element of active cooling into an otherwise passive system requires an energy input. The report suggests that this could be achieved



using solar power in most conditions. Active cooling will also reduce the number of days when an otherwise totally passively ventilated and cooled building becomes uncomfortable, and will reduce the demand for energy intensive cooling systems.

The report concludes with indicative drawings showing the implications of incorporating this type of ventilation into different building types and a note on the urban planning issues involved. Conclusions are drawn from experience with regard to some of the necessary building components. The conclusion also identifies the further work that is required before the strategies that are suggested can be adopted with confidence in everyday buildings.

New Publication from AIVC Bookshop

A Directory of Gas Sensor Research at UK Universities

A Publication of the Gas Analysis and Sensing Group, Electrical Engineering Department, University of Wales, UK

This document was funded by the Gas Analysis and Sensing Group and provides a detailed review of gas sensor research and development activities at UK universities; an activity that presently involves at least 195 workers. It identifies 53 individual research groups from 40 universities who have published and/or actively worked on this topic since 1994. It includes summaries of their research activities, details of group size and research funding, listings of the gas species under study, information on the techniques and technologies involved, and full contact details for key workers within each group. Information is also provided on collaborations with industry and other aspects of exploitation and commercialisation such as LINK schemes and SMART awards. The document concludes with three appendices and a list of 206 references.

It is available from the AIVC Bookshop, price £96.00.

One Day Seminar: Building Ventilation Design: Solutions through Understanding

28th October 1999

Institution of Mechanical Engineers Headquarters, London

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GUIDES

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Garage Ventilation, 1994, (BIB2)
Natural ventilation, 1994, (BIB3)
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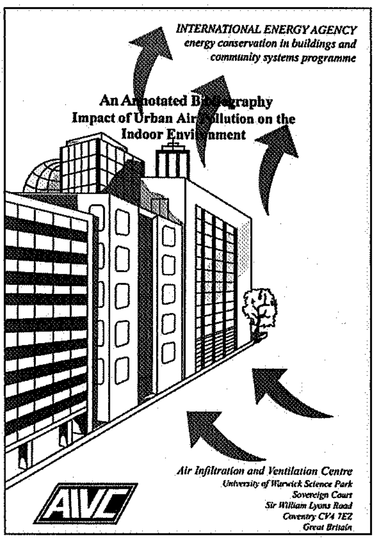

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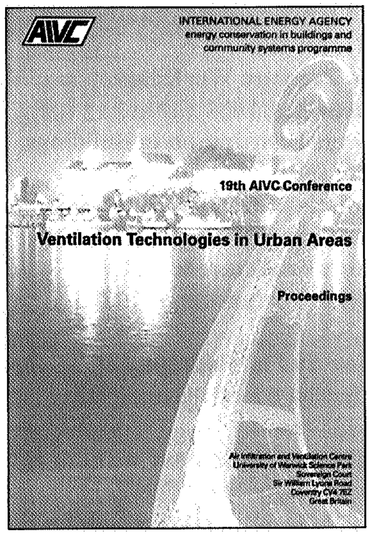

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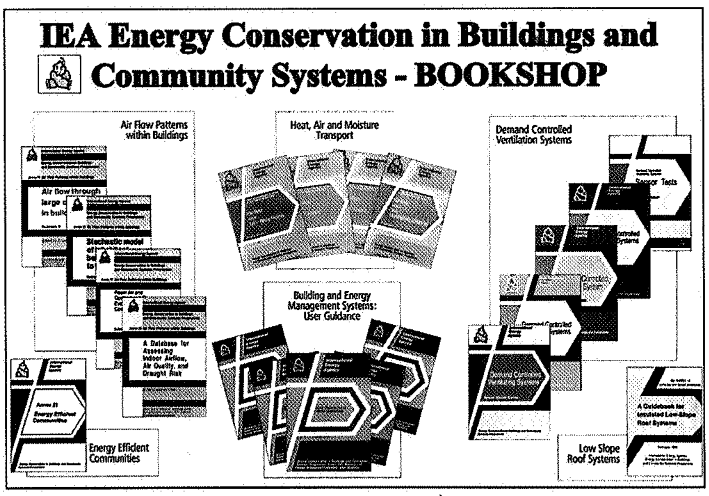

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ASTM Symposium on Air Quality and Comfort in Airliner Cabins
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Helsinki, Finland
Occupational Health for Europeans '99, Finnish Institute of Occupational Health, Ella Hanninen, Topeliuksenkatu 41a 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

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Ventilation 2000 6th International Symposium on Ventilation for Contaminant Control
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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
The Symposium will cover all the main areas of industrial ventilation, especially those that are important in the 2000s. Special attention will be given to breakthrough research findings of international significance, such as target levels and the systematic design of work rooms, new concepts in air distribution, and the life-cycle concept of ventilation technology.

Healthy Buildings 2000
6-10 August 2000
Espoo, Finland
Conference Secretariat, Healthy Buildings 2000, PO Box 25, FIN-02131 Espoo, Finland, Fax: +358 9 4355 5655 email info@sisailmayhdistys.fi internet www.hb2000.org www.sisailmayhdistys.fi

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The University of Reading, UK
Roomvent 2000, Dr Hazim Awbi, Department of Construction Management & Engineering, The University of Reading, Whiteknights, Reading RG6 6AQ, UK, Tel: +44 118 931 8198, Fax: +44 118 931 3856, email: rv2000@rdg.ac.uk, URL: http://www.rdg.ac.uk/rv2000
The conference aims to cover topics including: prediction of air distribution in rooms by analytical, numerical or physical modelling techniques; indoor air quality and thermal comfort; ventilation strategies; measurement and visualization techniques; characterization of heat and contaminant sources; impact of building envelope on the indoor environment; indoor climate performance in occupied buildings.

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