Air Infiltration Review

a quarterly newsletter from the IEA Air Infiltration and Ventilation Centre

International Energy Agency - AIVC

Vol. 14, No. 3, June 1993

The Ventilation of Dwellings

A Report on IEA Annex 27 - The Evaluation and Demonstration of Domestic Ventilation Systems

by Martin W. Liddament, Head of AIVC

It is variously estimated that up to 90% of our time is spent in buildings; much of which is in the home. Hence, the environment in dwellings has significant importance with respect to the health, comfort and well-being of occupants. In attempting to improve comfort in the home, much effort has concentrated on increasing the thermal insulation of the building shell to prevent unnecessary heat loss. In recent years, insulation standards have developed considerably in all IEA countries, as have improvements in design to minimise the risk of thermal bridging and consequential condensation. While much is now understood about the thermal performance of buildings, the role and application of ventilation often still remains a secondary consideration.

In recent times, increasing demands have been placed on the ventilation load in the home as a consequence of changing life-styles and the introduction of many polluting sources into the building. Arguably, the fundamental role of ventilation is to meet the metabolic needs of occupants. However, it is also needed to dilute and remove unavoidable pollution generated within the building. Dwellings present particular problems, since considerable amounts of water vapour may be generated through cooking, washing and clothes drying. In addition, other pollutants may be emitted from cooking and heating appliances, from other household activities and from furnishings and fittings. Ventilation to meet these needs can often represent a considerable energy penalty, while inadequate ventilation control, through poor design or excessive air infiltration, may further add to unnecessary energy loss and may also contribute to poor air distribution.

Methods of ventilation are diverse with the choice largely being dominated by climate, cost and a remedial response to problems as they arise.

In this issue

Occupancy patterns also vary widely and have a major impact on the adequacy of performance of a ventilation system. In addition the presence of combustion appliances, open chimneys, adventitious leakage openings and many other interacting parameters all combine to influence the safety and performance of individual approaches to ventilation. Further difficulties often arise because changes may be made to the balance of polluting sources brought about by the differing requirements of occupants as they move in to existing dwellings. A uniformly acceptable or a single approach to ventilation is therefore unlikely to provide an adequate or cost effective solution. Any system must be able to compensate and provide adequate ventilation according to these different and, often, continuously varying needs. Thus domestic ventilation presents complex problems, many of which still need to be identified and solved. The ultimate aim, nevertheless, is to provide reliable and energy efficient ventilation.

In early times, ventilation was provided by wholly natural means. In many instances, this simply meant relying on the natural porosity of the building, combined with window opening for summer cooling. To others, natural ventilation means the provision of purpose provided ventilators, frequently combined with a ventilation stack or chimney. More recently, several countries have introduced central mechanical systems for both single family and apartment buildings. These are normally based on either extract ventilation, with or without heat pump heat recovery, or on balanced supply/extract systems, which frequently incorporate air-to-air heat recovery. Even buildings that are ostensibly naturally ventilated are often fitted with extracting cooker, window or wall fans. Classifying the type of system fitted into a building is, itself, a difficult task. The motivation for mechanical ventilation, tends to come from areas subjected to severe extremes of climate. In these localities, it is particularly desirable to decouple the indoor environment from that of the outside. Buildings, therefore, tend to be constructed to a high degree of airtightness, while pre-conditioning of the incoming air is desirable to avoid discomfort. High energy loads are needed to heat (or cool) the air, thus increasing the attraction of incorporating heat recovery into the ventilation system. It is difficult to imagine a return to natural ventilation in countries that now routinely incorporate mechanical systems into new dwellings.

The position for milder climates is less clear. Costs of providing and maintaining mechanical systems can be high and may not necessarily be compensated by introducing heat recovery. The main argument used in support of mechanical systems in these regions is the need to provide consistent and controllable ventilation.

Whichever approach to ventilation is used, however, it is clear that much more effort is needed in understanding the role of ventilation and in implementing good design. Furthermore good design principles need to be applied to existing buildings as well as to new buildings.

IEA Annex 27

A new IEA Annex has been established to address some of these problems. Its principal tasks are to classify current methods of ventilating the home and to develop techniques which may be used to evaluate the performance of domestic ventilation systems. The intention is to provide the designer with a set of simple validated algorithms which will enable a reasonable assessment to be made of the energy and air quality impact of alternative ventilation strategies. It is further intended to demonstrate the performance of various domestic ventilation systems for various climatic conditions, construction types and occupancy patterns.

Scheduled to operate for five years, this Annex held its inaugural meeting at the TNO, Delft in the Netherlands on 21st-22nd April. Interested participants from nine countries were present, representing a diverse range of ventilation, building construction and climate types.

In introducing the Annex, the Operating Agent, Lars Goran Mansson, indicated that the ventilation of dwellings in IEA Countries accounted for approximately 10% of all energy consumed. Furthermore, despite the recent introduction of

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.

Conclusions and opinions expressed in contributions to Air Infiltration Review represent the author(s)' own views and not necessarily those of the Air Infiltration and Ventilation Centre.

mechanical ventilation systems in some countries, the dominant form of domestic ventilation is still natural. Lars also stated that the occupancy density of dwellings averaged approximately 2.5 people for each dwelling.

The current focus for this Annex concentrates on the implications for space heating energy rather than cooling. It is also aimed at three target groups, these being building inspectors, designers and researchers.

This Annex has been sub-divided into three Subtasks.

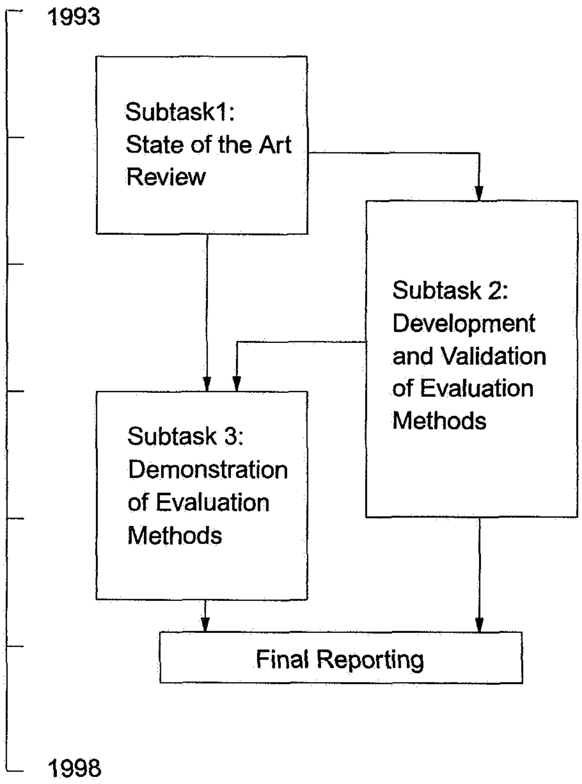


Figure 1: Annex 27 - Programme Plan

Subtask 1 is concerned with undertaking a comprehensive review of the current methods used to ventilate the home. This review will include an evaluation of the proportion of each type of system in use and the distribution of systems according to climate zone, country, building age and construction type (eg high rise, low rise, construction material,etc). Ventilation methods will be categorised according to a standard set of system types. These have yet to be defined but examples include ventilation by infiltration, window opening, purpose provided natural ventilation, local extract fans, central ventilation by extract, balanced ventilation, use of heat recovery, etc.

This survey will further endeavour to assess the rational behind the various methods in current use, especially in relation to Building Codes and Standards. The energy and indoor air quality impact, system cost and payback periods will also be evaluated. Additionally, existing methods of evaluating ventilation performance will be reviewed as part of this subtask.

The outcome of this task will be to develop a clear picture of present day approaches to ventilation and to assess the consequences of these systems in relation to energy use and the indoor environment. It is also intended that this task should provide a background against which improved domestic ventilation design can be compared.

Subtask 2 looks to developing new methods or improving existing methods to evaluate ventilation system performance. This is seen as the essential product of the Annex, with the ultimate goal being to provide the designer with a tool which may be used assess the energy and indoor air quality performance of a ventilation strategy in relation to the type of building construction, occupancy loading and climatic conditions (Figure 2). This development will be supported by a series of validation tests.

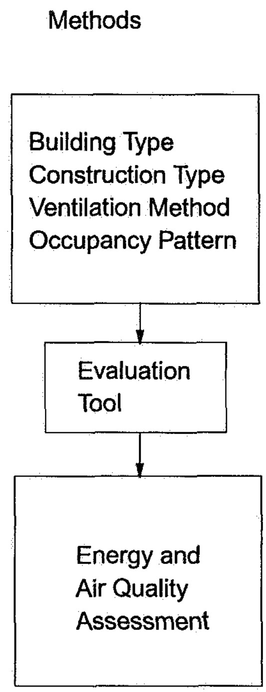


Figure 2: Subtask 2 Development of Evaluation Methods

Aspects under consideration include energy use, life cycle costs, system reliability and maintenance needs, flow patterns, occupancy interaction and air quality parameters.

Subtask 3 will focus on demonstrating and using the evaluation tools developed in subtask 2 to assess the performance potential of ventilation strategies. This will illustrate to the designer how the techniques may be applied to assess the range of applicability of different ventilation methods. Examples will be based on systems in current use and innovative systems for use in future building design.

Annex Participation

Annex 27 is scheduled to operate for a total of 5 years which includes a 1 year preparation phase and a 4 year operational phase. Individual country participant commitment is for a minimum of 39 months of effort. Countries that have indicated an interest in the project, although, as yet, not necessarily committed themselves to taking part, are: Belgium, Canada, France, Finland, the Netherlands, Norway, Sweden, the United Kingdom and the United States of America. There is still time for organisations in other countries to join. Interested organisations should make immediate contact with their ExCo representative and/or contact the Operating Agent for this Annex:

Mr. Lars Goran Mansson
LGM Consult AB
Adler Salvius vag 87
S-146 00 TULLINGE
SWEDEN

Tel: +46 (0)8 778 5006
Fax: +46 (0)8 778 8125

Demand Controlled Ventilating Systems - Sensor Tests

Per Fahlén, Head of R & D at the Laboratory of HVAC, The Swedish National Testing & Research Institute, Boras, Sweden

Background

A fundamental prerequisite for demand controlled ventilating systems is the possibility of finding a measurable "indicator" of the air quality. Another important factor is the existance of commercially available sensors for the measurement, which have acceptable sensitivity, accuracy, long term characteristics and price levels.

Different types of "indicators" can provide different types of information concerning the ventilation requirements of a specific building. Furthermore, different types of sensors for the same "indicator" can give different results. Such sensors must be sensitive enough to detect changes in the air quality requiring increased or decreased supplies of outdoor air and simultaneously be stable enough to function satisfactorily over long periods in varying environments.

Hence it is of great value to increase our knowledge concerning questions such as:

- which "indicators" are suitable;
- which sensors are possible for the planned "indicators";
- how do the different "indicators" read relative to each other;
- how do different sensors for one particular "indicator" read in the short term as well as in the long term.

Project Description

Sensors for the following types of indicators (in accordance with the scope of IEA Annex 18) were included in a laboratory performance test at SP (Swedish National Testing & Research Institute):

- Water vapour (RH, WBT, DPT)
- Carbon dioxide
- Non-oxidized gases (VOC, e.g. C_mH_n, CO, etc).

The tests consisted of two main parts. In the first part one specimen of each sensor type was extensively laboratory tested and in the second part three specimens of each sensor type were exposed to normal indoor climatic conditions.

Thus four specimens of each sensor type were included. To limit the size and cost of the project, testing was planned for a maximum of fifteen sensors (seven for water vapour, three for carbon dioxide and five for non-oxidized gases). In the actual test it was not possible to include more than two carbon dioxide sensors due to delivery problems. Instead another humidity sensor was included to give the same total number of sensors. The following presentation mainly pertains to the laboratory part of the test program.

The laboratory tests consisted of the following four main parts:

- Checking of the manufacturers' data sheets and instructions;
- Determination of the performance of new sensors including comparisons with data sheets;
- Determination of the cross-sensitivity of sensors exposed to various combinations of the three chosen indicators as well as variations in the power supply, atmospheric pressure, temperature and air velocity;
- Environmental tests concerning exposure to dry heat, dry cold, humidity, temperature change, vibration, electromagnetic radiation and electrostatic discharge.

Sensors were selected and tested by the respective manufacturer prior to delivery to SP. The sensors were installed in the laboratory as described by the manufacturer's instructions. Prior to the test the manufacturers were asked to provide technical information in accordance with a proposed standardized data sheet. This information was noted as background information to be compared with the test results.

Performance of New Sensors

The sensor performance was defined in terms of parameters such as *warming up time, zero drift, linearity, repeatability, hysteresis, stability, accuracy, sensititity, rise time, and cross-sensitivity* (sensitivity to influence factors). Some selected results from the presentation by Fahlén et al are given below.

The *warming up times* were only measured for the humidity sensors. One half of these sensors had negligible warming up times (less than 0.5 min). The other half of the humidity sensors had warming up times in the range 30-70 min. The VOC-sensors on the other hand have two different warming up times, one after a short interruption of the power supply and one after the heated sensing element has been permitted to cool down. These were not determined in this investigation but the long term warming up time may be as long as a fortnight or even up to a month according to the manufacturer.

Some results from determinations of sensor characteristics are summarized in Table 1. *Linearity* was calculated as the maximum deviation between any measured value and a straight line between two specified rating points. *Hysteresis* and *sensitivity* were calculated in a similar manner with the sensitivity defined as the change in output between fixed rating points divided by the corresponding change in input (e.g. V/% RH). Sensor no. S14 is equipped with two sensing elements, one for humidity (S14A) and one for VOC (S14B).

Sensor no.	Linearity	Hysteresis	Sensitivity
S1 VOC	1 (%AQ)	0.9 (%AQ)	0.28 (V/ mg/ m^3)
S2 VOC	-*	-*	-*
S3 VOC	-*	-*	-*
S4 VOC	3.5 (%AQ)	0.3 (%AQ)	0.046 (V/ mg/ m^3)
S5 CO2	98 (ppm CO_2)	18 (ppm CO_2)	0.0038 (V/ ppm CO_2)
S6 CO2	26 (ppm CO_2)	21 (ppm CO_2)	0.0047 (V/ ppm CO_2)
S7 RH	1.2 (%RH)	0.7 (%RH)	0.15 (mA/ %RH)
S8 RH	1.2 (%RH)	0.8 (%RH)	0.0091 (V/ %RH)
S9 RH	2.7 (%RH)	2 (%RH)	0.076 (V/ %RH)
S10 RH	1.2** (%RH)	0.2** (%RH)	0.078 (V/ %RH)
S11 RH	2.3 (%RH)	0.4 (%RH)	0.15 (mA/ %RH)
S12 RH	1.1 (%RH)	0.8 (%RH)	0.15 (mA/ %RH)
S13 RH	1.2 (%RH)	0.7 (%RH)	0.14 (mA/ %RH)
S14 RH/ VOC	2.2 / 2.2 (%RH / %AQ)	0.6 / 1.4 (%RH / %AQ)	0.0054 (V/ %RH)/ 0.0098 (V/mg/m^3)
S15 RH	4.7 (%RH)	1.4 (%RH)	0.094 (V/ %RH)

* The response of the sensor was too small to be significant or the results were inconclusive.
**Some other specimens of this sensor type had deviations ten times this value.

Table 1: Results from determinations of the sensor characteristic curve.

The reference gas for testing VOC-sensors was composed of one aldehyde (octanal, $C_7H_{15}CHO$), one aromatic hydrocarbon (toluene, C_7H_8), and one aliphatic hydrocarbon (nonane, C_9H_{20}). These substances were intended to represent organic compounds that are frequently found in the analysis of air from e.g. office buildings.

During the determination of the characteristic curve the VOC-cocktail was composed of equal parts of the three constituents. At one test point, however, tests were also performed with the total concentration consisting of only one of the reference gases at a time. It was found that for this particular cocktail, and with these particular sensor types, changing the composition had no significant influence on the result.

VOC-sensors were also tested with tobacco smoke corresponding to two levels of smoke concentration at each of three different flowrates (minimum flow for a non-smoking environment, minimum flow for a smoking environment and the maximum flowrate of the system). Cigarettes were smoked by an "artificial smoker" to achieve a reproducible test. In Figure 1 the response of VOC-sensors S1, S2, S3, S4 and S14 are shown for a case of 10 cigarettes smoked simultaneously at a condition of minimum ventilation rate for a non-smoking environment. The diagram indicates that although this is a case of extreme smoke pollution one of the VOC-sensors does not react at all and another only reacts to a very small extent.

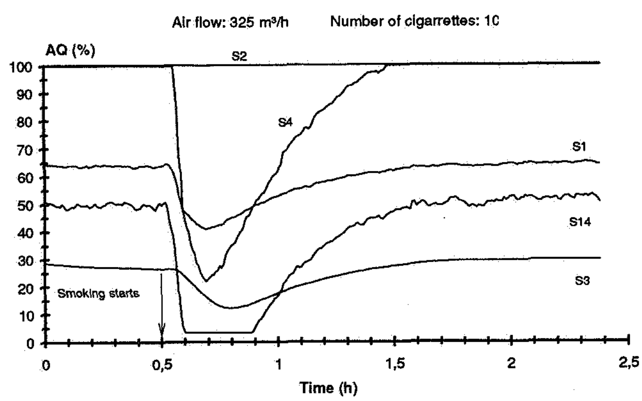


Figure 1: Response of VOC-sensors when 10 cigarettes are smoked simultaneously at a condition of minimum ventilation rate for a non-smoking environment.

All sensors performed acceptably with regard to *repeatability* and *stability*. Deviations ranged between 0.1-1.1 %. The *rise time* and *fall time*, respectively, were also measured and calculated as the time between a change of input until the output had changed to 90% of the steady state value. The rise times of most humidity sensors were acceptable (1-10 min.). Sensor S10, however, had a rise time exceeding 1 h and a fall time of 18 min, figures which would not be acceptable for control purposes. Rise times for carbon dioxide and VOC-sensors were not evaluated.

The sensitivity of sensors to various influence quantities was tested by varying, one at a time, influence quantities such as temperature, humidity, voltage, frequency, atmospheric pressure and composition, and tobacco-smoke. The *cross-sensitivity* was expressed for each influence factor as the ratio between total change in output and total change in input. Voltage, frequency, temperature and humidity all affected the CO_2 sensors to some extent. Sensor S5, for example, changed its output by 50 ppm for either of the following changes: 15 V of supply voltage, 3 Hz of supply frequency, 7 Deg. C of ambient temperature, and 20 % RH of ambient humidity. During the smoking experiments it was also found that the CO_2 sensors were slightly influenced by tobacco-smoke. VOC sensors were generally influenced by changes in temperature and humidity whereas the humidity sensors seemed tolerant to all the selected types of influence factors.

Environmental Tests

Environmental tests were performed to check the resistance of a sensor to possible extreme situations in the environment within the field of application of the sensor. Tests were carried out concerning *climatic, mechanical* and *electrical parameters*.

Climatic tests were performed in accordance with IEC standards on low temperature, dry heat, damp heat and change of temperature. Similarly, *mechanical* tests were performed in accordance with the IEC standard on random vibration whereas *electrical* tests were performed in accordance with IEC standards on conducted bursts, electrostatic discharge, electromagnetic radiation and surge voltage immunity. In Figure 2 an example is shown of the output from a humidity sensor during the environmental tests. Note that the output changes between -20% and more than 100 % RH (the scale is limited to 80%) while being exposed to electrical transients. The actual humidity is around 40% RH during this test.

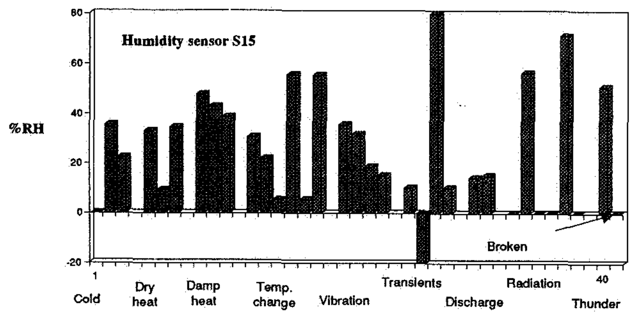


Figure 2: The output signal of humidity sensor S15 during the environmental tests.

Few sensors endured the entire environmental test program. Vibration, electrostatic discharges or surge voltages ("thunder") caused 12 of the 15 sensors to fail. Furthermore, the outputs of most sensors were greatly affected during the actual transient bursts. The output of one humidity sensor (S15), for instance, changed from 1 V to -10 V and another (S13) changed from 3.8 V to 25 V. One CO_2 sensor changed its output from 10.3 V to 40 V and then slowly died altogether. Tests with radiated electromagnetic interference clearly indicated that this type of interference is a potential source of trouble. Even though the behaviour of individual sensors was quite different in detail all sensors changed their outputs by several orders of magnitude at specific frequencies or frequency ranges.

Final Test

Finally, the characteristic curves of the surviving sensors were checked again. The result for one of the sensors is shown in Figure 3. This sensor, humidity sensor S8, has endured all tests extremely well.

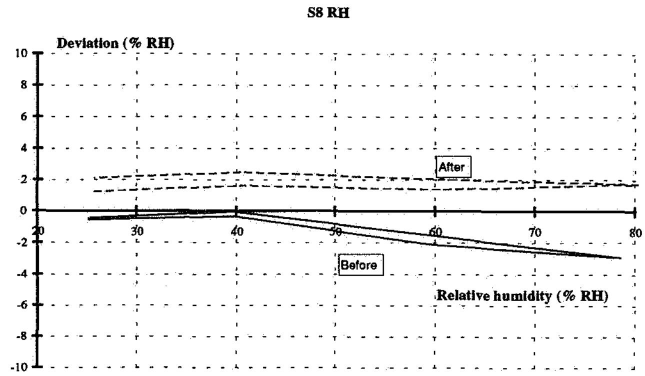


Figure 3: The characteristic curves of humidity sensor S8 before (full line) and after (dashed line) the environmental testing.

Parallel to the environmental tests in SP's laboratories three specimens of each sensor type were installed in actual buildings. One was installed in a conference room, one in a cell-type office and one in a laboratory room. Figure 4 illustrates the change in the sensor characteristic curve after approximately one year of operation in a conference room.

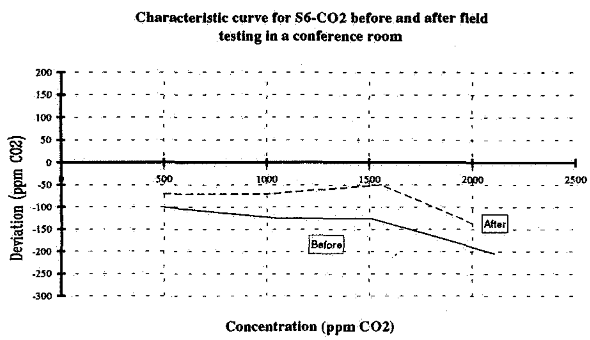


Figure 4: The characteristic curve of one sensor of the type S6 before (full line) and after (dashed line) one year of operation in a conference room.

Conclusion

The test results indicate that capacitive humidity sensors are well suited for the control of humidity levels in buildings. The combined error of linearity, hysteresis and repeatability is normally below 5% RH at 20° C. The cross-sensitivities to variations in the ambient temperature and power supply (voltage and frequency) are acceptable and the cross-sensitivities to hydrocarbons, carbon dioxide and tobacco smoke are negligible. A plastic strip humidity sensor, on the other hand, proved less suitable due to excessive hysteresis and linearity errors.

Carbon dioxide sensors show acceptable performance for control purposes with a deviation of less than 50 ppm at a level of 1000 ppm. Sensor calibration and/or adjustment is however a time consuming process. These sensors are also sensitive to humidity below a threshold level.

The mixed gas sensors indeed show a mixed behaviour. Some react strongly to tobacco smoke, some slightly and one hardly at all. On the other hand, all of them seem quite sensitive to humidity. Tests with varying compositions of the chosen VOC cocktail indicated little difference in the response to the individual components.

All sensors endured the climatic tests reasonably well. Mechanical vibration of the other hand caused some of the sensors to break. Radiated electromagnetic fields affected all sensors and the electric shock due to a simulated strike of lightning proved too much for most of the sensors.

The environmental tests were decisive in the respect that only three out of fifteen sensors survived all of the tests. These results notwithstanding, the test conditions were chosen to represent favourable operating situations that e.g. household electronics may encounter. It must, however, be borne in mind that laboratory tests are one thing and the facts of real world situations may be quite a different cup of tea. Future in situ evaluations will hopefully provide further useful information in this respect.

Reference

1. Fahlen P, Andersson H, Ruud S, 1992, Demand Controlled Ventilating Systems - Sensor Tests. (Statens provningsanstalt) SP Report 1992:13, Boras.

New AIVC Review

Ventilation and Infiltration Characteristics of Lift Shafts and Stairwells A Selected Bibliography

By Mark Limb, January 1993

The stack effect provides the driving force for vertical air movement within buildings. Its effects are especially pronounced in high rise developments, where the air leakage associated with elevators, stairs and service shafts can be a major concern. Stairwells and lift shafts themselves provide occupant access to those floors above or below ground level as well as providing routes for the movement of air. A knowledge therefore of the air movement characteristics of such shafts is vital in understanding the ventilation and leakage patterns in medium and high rise buildings. Such work has been particularly helpful in the prediction and evaluation of smoke control procedures.

This AIVC review attempts to outline the main areas of research that have been undertaken in the evaluation and understanding of air leakage characteristics of both stairwells and lift shafts.

The review identifies the importance of stairwell and lift shaft air flows in tall buildings. Of primary interest are the characteristics and mechanisms of such air flows for the prediction of heat moisture and pollutant transport throughout buildings. The restriction and control of smoke and fire in vertical stair wells and lift shafts has also generated much interest along with the associated effects of stack pressures and the resulting air leakage characteristics especially in tall buildings. The interaction of these concerns with ventilation systems has also been an area of focus. Most papers cited in this review deal with the fundamentals of airflows in stairwells and lift shafts. Many use models to predict these phenomena as well as experimental data from test and real buildings. These examples provide important background guidelines for further research.

A copy of the full review, including a detailed text and bibliography, is available from AIVC Information Services.

14th AIVC Conference, Copenhagen, Denmark

September 21-23, 1993

Preliminary Programme

Registration/Reception, 19.30hrs Monday, 20th September, 1993, Palace Hotel, Copenhagen

Tuesday, 21st September, 1993

INDUSTRIENS HUS CONFERENCE CENTRE

Free copy of AIRBASE with every conference place

Morning - Opening & Keynote Presentation

Session 1: Ventilation & Energy

Ventilation Rates and Air Tightness Levels in the Swedish Housing Stock. *J Kronvall, C-A Boman (SWE)*

Potential Energy Savings from Modified Ventilation of Dwellings. *N. Bergsoe (DEN)*

Ventilation-Energy Liabilities in US Dwellings. *M. Sherman, N. Matson (USA)*

The Energy Impact of Ventilation & Air Infiltration in an Atrium. *A Blomsterberg, M Wall (SWE)*

The Energy Impact of Ventilation on Industrial Buildings; The Implications of Low Infiltration Rates on Ventilation Effectiveness in Factories. *P.J. Jones, D K Alexander, G. Powell, (UK)*

Theoretical Basis for Assessment of Air Quality & heat Losses for Domestic Ventilation Systems in France. *J-G Villenave, J-R Millet, J. Riberon (FRA)*

Afternoon - Session 2: Ventilation Systems (Posters)

Ventilation Efficiency Measurements in a Test Chamber with Different Ventilation & cooling Systems. *C-A Roulet, P. Cretton (SWITZ)*

Ventilation Related Aspects in the CEC-PASCOOL Project on Passive Cooling Strategies. *M. Santamouris (Greece), L.Vandaele (BEL), F.Allard (FRA)*

Efficient "Horizontal Flow" Ventilation: Influence of Supply Inlet Designs. *Y-Q Tang, S Holmberg (SWE)*

Stratified Flow in a Room With Displacement Ventilation. *P V Nielsen (DEN)*

Natural Ventilation without Draught. *M Egedorf (DEN)*

Mechanical Ventilation System with Heat Exchanger in One Room - Low Cost Mechanical Ventilation System. *M Egedorf (DEN)*

Some Aspects of Using Jets for Cooling. *T Karimipanah, M. Sandberg (SWE)*

The Effect of Various Inlet Conditions on the Flow Pattern in Ventilated Rooms - Measurements and Computations. *G Morgenstern, E. Richter, M. Rosler, P. Vogel (GER)*

Theoretical & Experimental Simulation of Exhaust Hoods. *M Di Tommaso, G. Fracastoro, E. Nino, M. Perino (ITA)*

Demand Controlled Ventilation in an Auditorium. *S.Svennberg, L-G Mansson (SWE)*

Development & Investigation of a Combined Ventilation & Floor-Heating System. *F Steimle, B. Mengede (GER)*

Simulation of Displacement Ventilation and Radiative Cooling. *M Koschenz (SWITZ)*

Energy and Cost Impact of Residential Ventilation Control Strategies. *D.J. Shah, D.Wahlstedt (USA)*

Energy Implications of Domestic Ventilation Strategy. *S Palin, R. Winstanley, D. McIntyre, R. Edwards (UK)*

Cooling Ceiling Systems & Displacement flow. *G Mertz (GER)*

Stack Effect Ventilation of An Infants School. *J Palmer, M. Trollope, R. Watkins (UK)*

Benefits and Limits of Free Cooling in Non-Residential Buildings. *A Bollinger, H Roth (GER)*

Wednesday, 22nd September, 1993

Morning
Session 3: Ventilation & Indoor Air Quality

Moisture Admittance Model: Measurement in a Furnished Dwelling. *L Serive-Mattei. R Jones, M.Kolokotroni, J. Littler (UK)*

The Influence of the Humidity on Thermal Comfort, Heat Load Calculation & Cooling Capacity. *F Steimle (GER)*

The Pleiade Dwelling: An IEA Task XIII Low Energy Dwelling with Emphasis on IAQ & Thermal Comfort. *P Wouters, D. L'Heureux, A. De Herde, E. Gratia (BELG)*

The Influence of Purpose-Provided Openings on Natural Ventilation of Buildings Equipped with Gas-Fired Appliances. *R Borchiellini, M. Cali, M. Girard, M. Masoero (ITA)*

Natural Ventilation via Courtyards: Part I - Theory & Measurements. PART II- CFD As An "Idea Generating" Tool. *L Shao, R.R. Walker, M. Woolliscroft (UK)*

Flow Paths in a Swedish Single Family House - A Case Study. *L Jensen (SWE)*

Local Exhaust Ventilation - A Numerical & Experimental Study of Capture Efficiency. *U Madsen (DEN)*

A Guide to Ventilation Assessment in a Mechanically Ventilated Commercial Building. *A K Persily (USA)*

A New Development of Total Heat Recovery Wheel. *F Dehli (GER)*

Modelling Adjustable Speed Drive Fans to Predict Energy Savings in VAV Systems. *D Lorenzetti, J. Axley (USA)*

Afternoon
Session 4: Ventilation Energy & IAQ (Posters)

High Comfort to Reasonable Cost. *B. Barath (GER)*

Clean Room Technology. *J Pedersen (DEN)*

Energy Impacts of Attic and Roof Construction. *W B Rose (USA)*

Programme for Energy Efficient & Healthy Apartment Buildings in Stockholm. *L Fyrhake, P-A Hedkvist, M Hult (SWE)*

Utilizing Ventilation Pressures to Control Radon & Other Outside Pollutants while Increasing Comfort, Energy Efficiency & Indoor Air Quality in a Residence. *M Nuess (USA)*

Long-Term Performance of Residential Ventilation Systems. *M-L Pallari, M. Luoma (FIN)*

Ventilation of Public Swimming Pools. *D Dickson (UK)*

The Influence of Indoor Tobacco Smoking on Energy Demand for Ventilation. *L-G Mansson, S.Svennberg (SWE)*

The Variation of Heat Loss Through Suspended Floors With Ventilation Rate. *D J Harris, S. Dudek (UK)*

Natural Ventilation Characteristics & Indoor Air Quality of Buildings. *G Beccali, G. Cannistraro, G. Giaconia, G. Rizzo (ITA)*

Indoor Air Quality Index. *D Creuzevault (FRA)*

Correlations Between CO2 And Steam Concentration Measured in 60 Occupied Housing Units. *P Dalcieux (FRA)*

Natural Ventilation in 18 Belgian Apartments: Final Results of Longterm Monitoring. *P Wouters, D. L'Heureux, B. Geerinckx (BELG)*

Practical Aspects of Energy Rating within the UK. *C Irwin, R. Edwards (UK)*

A PMV Controlled Ventilation Strategy. *P Simmonds (NETH)*

Assessment of Energy Impact of Ventilation & Infiltration in the French Regulations for Residential Buildings. *J Riberon, J-R Millet, J-G Villenave (FRA)*

Thursday, 23rd September, 1993

Morning
Session 5 Measurement Techniques (Posters)

Development of a New Tracer-gas Sampling System/Computer Modelling & Measurement of Airflow in an Environmental Chamber. *S.B. Riffat, K S Kohal, K W Cheong (UK)*

Flow of Aerosol Particles Through Large Openings *N M Adam, S.B. Riffat (UK)*

Interaction between Infiltration & Mechanical Ventilation in Multi-Room Buildings. *Yuguo Li (Australia)*

Dilution vs. Displacement Ventilation in Terms of Air Diffusion Effectiveness. *N O Breum (DEN)*

Influence of Air Infiltration on Heat Losses in a Multifamily Dwelling House. *A Baranowski (POL)*

Tests and Simulation of Air Flows in Multizone

Buildings: The Alternative Method of Complex Analyses. *M B Nantka (POL)*

Energy Impact of Ventilation and Dynamic Insulation. *B. Hedin (SWE)*

Distributions of Expected Air Infiltration & Related Energy Use in Buildings Based on Statistical Methods with Independent or Correlated Parameters. *A Nielsen (NOR)*

A Four Zone Ventilation Test Facility. *C E Brouns, J R Waters (UK)*

The Evaluation of Ventilation Effectiveness Measurements in a Four Zone Laboratory Test Facility. *J. Waters, C. Brouns (UK)*

Application of a New Method for Improved Multizone Model Predictions. *A Schaelin, V. Dorer, J. Van Der Maas, A. Moser (SWITZ)*

Balancing Ventilation Systems Using Thermography. *I C Ward (UK)*

Thermography: Its Applications for Building Air Leakage Measurements. *J W Roberts, I. Ward (UK)*

Visualization of Measured Three-Dimensional Well-Mixed Zones of Temperature & Humidity in a Ventilated Space. *M De Moor, D Berckmans (BEL)*

A New Method for Assessing Room Air Distribution Strategies. *H B Awbi (UK)*

Afternoon
Session 6: Ventilation Modelling & Simulation

Neutral Pressure Levels in a Two-Storey Wood Frame House. *J.T.Reardon, C-Y Shaw (CAN)*

Measurements of Air Change & Energy Loss with Large Open Outer Doors. *A Nielsen, E. Olsen (NOR)*

Laboratory Measurements on Vertical Air Flows in a Large Horizontal Opening. *K Klobut (FIN)*

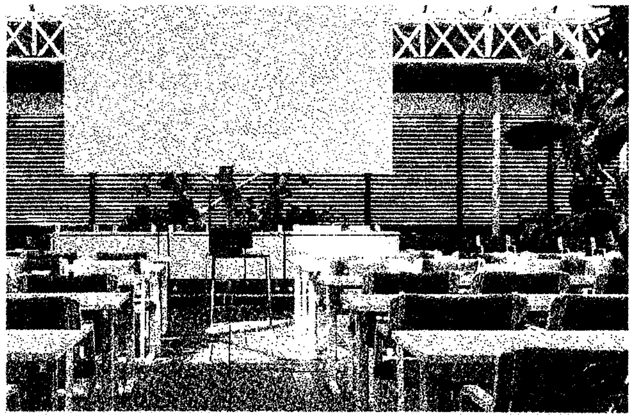
Multi-zone Cooling Model for Calculating the Potential of Night Time Ventilation. *J Van der Maas, C-A Roulet (SWITZ)*

Comparison of Multizone Air Flow Measurements & Simulations of the LESO Building Including Sensitivity Analysis. *V Dorer, J-M Furbringer (SWITZ)*

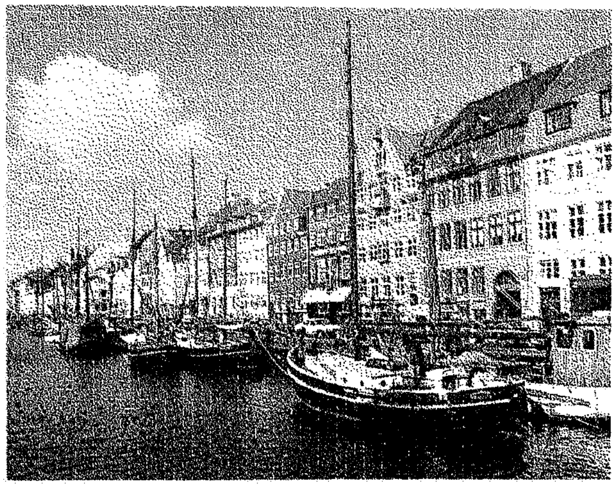
Proximity Effects: Air Infiltration & Ventilation Heat Loss of a Low-Rise Office Block Near a Tall Slab Building. *M D A E S Perera (UK)*

Measured and Simulated Energy Impacts of Increased Ventilation in a High-Rise Office Building. *J. Ventresca (USA)*

Summing Up
Conference Ends approx 4.30pm



(Above) Inside the Industriens Hus Conference Centre.
(Below) Copenhagen's Nyhaven.



Review of Sick Building Syndrome

Dipl.-Ing. Jürgen Röben

Institute of Applied Thermodynamics and Air-Conditioning

University of Essen, Germany

1. Introduction

In recent years the terms "Sick Building" and "Building Illness" have been heard more and more often. This however does not mean that the actual building is sick. It rather means that the employees in the building do not feel well and have causes of complaint, which more or less fade out when the people leave the building. Not everybody who works in a "sick" building will get ill. It is similar to an influenza epidemic, which does not affect everyone either. There is no definite explanation for what the causes of the complaints in the building are, because there is a variety of possible factors.

When people who work in air conditioned buildings complain about health problems, they spontaneously blame the air conditioning system. We should however always consider the whole building, e.g. building materials, interior equipment, places of work, technical equipment of the building, location of the building, etc. There might as well be an increased concentration of pollutants caused by the evaporation from interior equipment, which can lead to health problems with the employees. The evaporation of formaldehyde from equipment can be seen as an example of immediate interest. This has led to substantial problems in recent times. Changing the carpet can very often be the solution to the problem and the number of complaints from occupants is consequently reduced to an acceptable rate.

A further important aspect is the way a building is used. A building e.g. which in the past was adequately designed for a certain purpose might not come up to present demands. An older office building could have had different owners and thus a different structure of rooms and interior equipment. Open-plan offices can have been rearranged to single offices, office rooms to business premises or stock rooms. Furthermore additional copiers, computers, etc. can have been installed. Such alterations inevitably lead to problems with the indoor air quality, because the ventilation/air conditioning system was designed for the original offices in the building.

This report is meant to give a brief survey of existing publications about the "Sick Building Syndrome". It reviews investigations from several different countries. The choice of the studies considered is mainly based on entries in the AIVC bibliographic data bank AIRBASE, which are marked accordingly (e.g. #NO 1968).

2. What is "Sick Building Syndrome"?

Different from "normal" illnesses like e.g. influenza, health problems often disappear when the affected people leave their places of work. The complaints only arise again when the employees return to their working environment. The people concerned are obviously reacting to their office environment. If a greater number of occupants have symptoms which are connected with their places of work, they frequently suffer from the so-called "Sick Building Syndrome". The symptoms which arise such as headaches, drowsiness, eye irritation, nose and throat infection, etc. are often comparable to those of a cold or influenza.

Even if the causes of the sick building syndrome are frequently emphasized differently, the indoor air quality is a problem in most of the cases. Usually airborne pollutants are responsible for this. The thermal comfort factors however also play an important role in this connection. This can be seen as the frequency of complaints about rooms which are too cold or too hot, air draught phenomena, etc. Further factors can be air humidity, lighting, noise, odour, but also aspects like health supporting office furniture, overcrowded rooms, and working conditions. Considering the psychological aspects and the fear of possible damage to health, we can imagine how many variable factors influence each other.

Furthermore the fact that thresholds of tolerance are different with every human being makes it difficult to find a definite cause of the sick building syndrome. Because of individually different metabolisms people produce different quantities of heat, so that there will always be disagreement between the employees about the choice of a certain room temperature. Often the room temperature is used to show the employees that they work under comfortable conditions. This procedure however is basically wrong, because in order to estimate the thermal comfort the following limiting quantities are of decisive importance:

- internal temperature

- internal humidity

- internal air velocity

- temperature of the surrounding surfaces

- activity, and

- clothing.

Thresholds of tolerance with human beings are also different referring to sensitivity to odour. Furthermore people's sense of smell weakens during longer stay in a building or a room, so that only persons who stay there for a short time can perceive existing odours.

Table 3.1: View of the compared work

Ref. #NO	Country	No. of buildings	Comparative study	Ventilation/air conditioning	Environmental measurement	Questionnaire
1968	Canada	1	no	Mechanical ventilation system (VAV)	temperature, humidity, supply of outdoor air, CO, CO_2	no
1968	Canada	2	yes	Building 1: naturally ventilated Buildig 2: mechanically ventilated	temperature, humidity, CO_2	yes
2896	Canada	1	no	HVAC, VAV-system	temperature, humidity, particulates, hydrocarbons, ventilation and air distribution, supply of outdoor air	yes
4227	Canada, UK, USA	7	no		no	yes
1733	Canada	2	yes	Building 1: naturally ventilated Building 2: HVAC-system	volume, velocity and mixture of supply and return air (air balance test)	yes
3262	Denmark	14	yes	6 buildings naturally ventilated, 3 mechanically ventilated, 2 supply/exhaust air system and recirculation, 2 supply/exhaust air system and humidifier; 1 only supply/exhaust air system	temperature, humidity, formaldehyde, dust, microorganisms, fibres, volatile organic compounds, lighting, noise, CO_2	yes
5215	Finnland	1	no	Most areas have simple mechanical ventilation with heat recovery and a small part of the building has air conditioning and humidification	airflow, temperature, humidity, pollutants, particles, ions, radon	yes
Kröl.	Germany	4	yes	2 buildings naturally ventilated; 1 HVAC, 1 partly HVAC and naturally ventilated	temperature, humidity, CO_2, air velocity, noise	yes
4404	NL	61	yes		no	yes
1506	Norway	1	no	HVAC-system	temperature, humidity, electrostatic discharges, noise, supply of outdoor air, air velocity, dust, pollutants	yes, but only environmental parmeters
4467	CH	26	yes		temperature, humidity, airborne nicotine, particulates, pollutants, CO, CO_2	no
1508	UK	2	yes	Building 1: HVAC-system, Building 2: naturally ventilated	no	yes
1510	UK	1	no	HVAC-system	temperature, humidity, air velocity, pollutants, bacteria	yes
1919	UK	2	yes	Building 1: naturally ventilated; Building 2: fully air conditioned	temperature, humidity, air velocity, ions	yes
2405	UK	9	yes	3 buildings naturally ventilated, 1 mechanically ventilated with recirculation air, 5 fully air conditioned	no	yes
4398	UK	15	yes	5 buildings fully air conditioned, 6 mechanically ventilated; 4 naturally ventilated	temperature, humidity, particulates, microorganisms	yes
4036	USA	1	no	HVAC-system (VAV, multi-zone)	formaldehyde, ozone, temperature, humidity, fungal spores (in- and outside), CO, CO_2, SO_2	yes

Table 3.1: View of the compared work

The great number of variable parameters makes it nearly impossible to please every individual in a building or room with respect to thermal comfort. Even with an optimum indoor climate we will always have to expect a certain number of complaints.

3. Selection of existing work

In AIRBASE, the bibliographic database of the AIVC, there are more than 150 items which use the term sick building, building sickness or SBS. Most of the literature describes only basic information about the sick building syndrome and in a few of them we can find investigations. In this report a small amount of existing work is used to compare the results of the questionnaires.

Table 3.1 shows a selection of studies which are compared with each other. The literature used is from different countries; Canada, Denmark, Finland, Germany, Netherlands, Norway, Switzerland, UK and USA.

4. List of symptoms

Most of the existing studies use questionnaires to find out what the building-related health problems of the employees are. The alphabetic list following in Table 4.1 shows a great number of symptoms which the employees concerned were asked about in different forms of questionnaires.

Table 4.1: Alphabetic list of symptoms

A	Aches, aches of arm, hand, wrist
B	Back ache, blocked nose, breathing
C	Chest pains or tightness, chills, circulatory disturbance, cold extremities, cold/flu, contact lense problems, cough
D	Depression, diarrhoea, difficulty concentrating, digestion problems, dizziness, drowsiness, dry skin
E	Eye, eye irritation
F	Faintness, fatigue, fever, flu-like
G	General
H	Headache, heavy tired legs, humidifier fever
I	Irritability, itchy nose, itchy skin
L	Lack of energy, lethargy
M	Menstrual, mucous membrane, muscle aches
N	Nasal, nausea, neck ache, nose bleed, nose irritation
O	Others
R	Rash, respiratory problems, rheumatic problems, runny nose
S	Shortness of breath, sinus congestion, skin, skin dryness or itching, skin rash, sleepiness, sore and irritated throat, stomach ache, stress, stuffy nose
T	Tension, throat, throat irritation, tight chest, trouble focusing
W	Watering eyes, weakness, wheeze

Table 4.1: Alphabetic list of symptoms

There are a lot of symptoms with similar meanings in this list and it is nessesary to make several symptom groups. This is important in order to compare the different studies with each other. Table 4.2 shows ten groups which were made for this report.

m.V ....mechanically ventilated
n.V .....naturally ventilated.

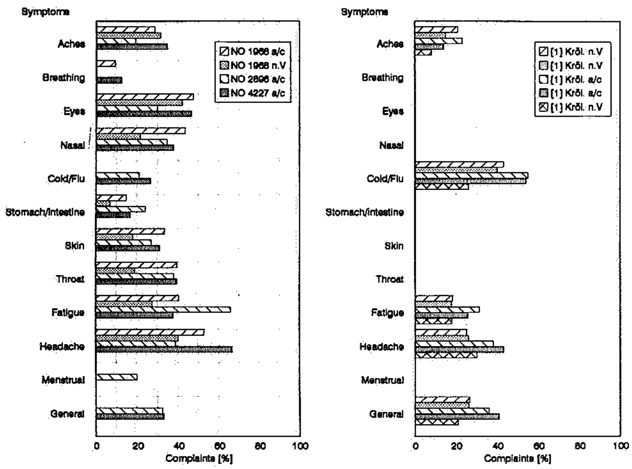


Figure 5.1: Prevalence of work-related symptoms in different studies

Figure 5.1 and also Figure 5.2 show generally there is a higher percentage of complaints in air conditioned buildings than in naturally ventilated buildings. The study NO 4398 is an exception, because the rates of the dissatisfied in the different symptom groups are very similar. In some groups the percentage of complaints in mechanically ventilated buildings is higher than in air conditioned ones.

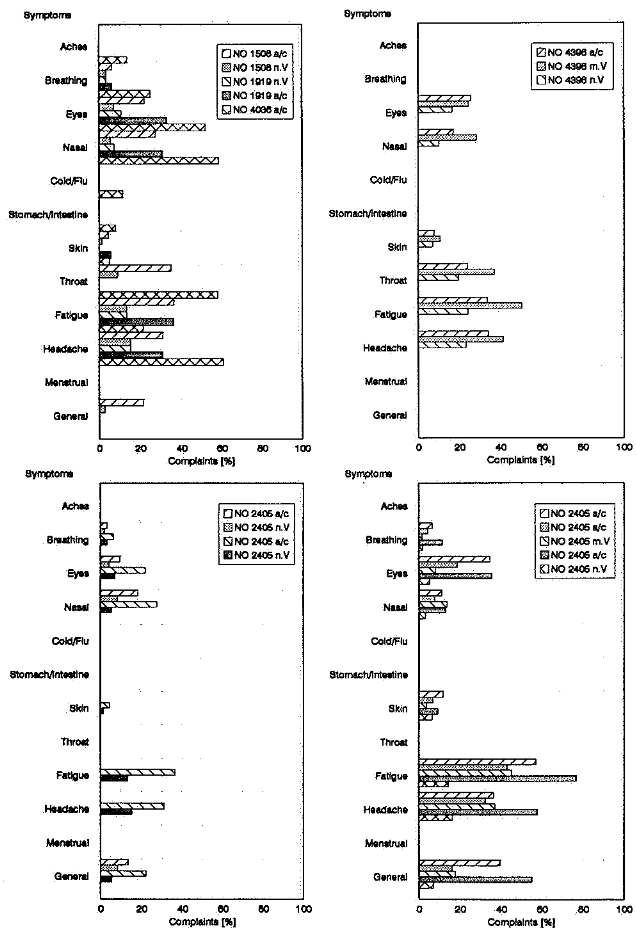


Figure 5.2: Prevalence of work-related symptoms in different studies

Figures 5.1 and 5.2 show no significant difference between the several countries. In each study the complaint about fatigue and headache is very often mentioned. In the symptom group fatigue lethargy is included and very often also accompanied by a headache. Headache and lethargy have many possible causes, including working all day under fluorescent lighting, spending too many hours in front of a visual display unit, lack of negative ions, lack of air movement, low humidity, ozone and carbon monoxide or formaldehyde from furniture and furnishings.

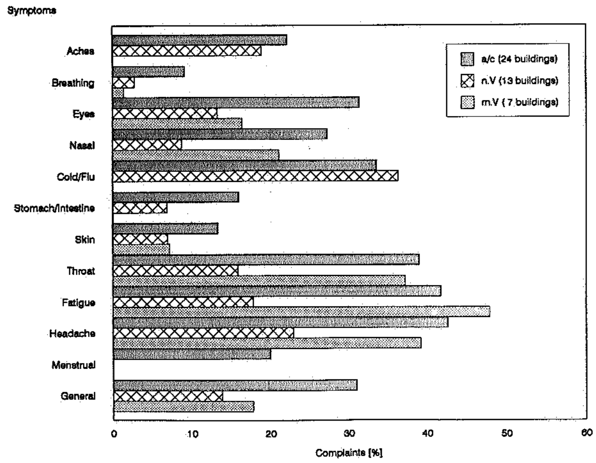


Figure 5.3: Summarized results of the studies

All studies and all investigated buildings respectively are summarized in Figure 5.3 to see a trend for the frequent complaints. Due to the different numbers of buildings which are divided into three groups, a statistical statement is not possible. The nine studies which are used here to show the percentage of complaints were all carried out in 24 air conditioned, 13 naturally ventilated and 7 mechanically ventilated buildings. Considering the results we can see that the air conditioned buildings come off badly, but the problem is that the number of the ventilated buildings is different. It is also possible that the next 11 naturally ventilated buildings - to have the same numbers of air conditioned and ventilated buildings - yield higher rates of dissatisfaction.

In this report only 9 of the 17 selected studies were compared. The reason therefore is that the data of the 8 studies which are not compared were not sufficient. Either the investigated buildings were not exactly described referring to the ventilating system or the percentage of complaints was not clearly assigned to the systems.

6. Outlook

Investigations into the phenomenon of sick building syndrome frequently make comparisons between air conditioned buildings in which there is a high rate of complaints or above-average absenteeism due to illnesses and naturally ventilated buildings. This is acceptable as long as the bad results of the air conditioned buildings do not lead to the conclusion that air conditioning generally causes illnesses.

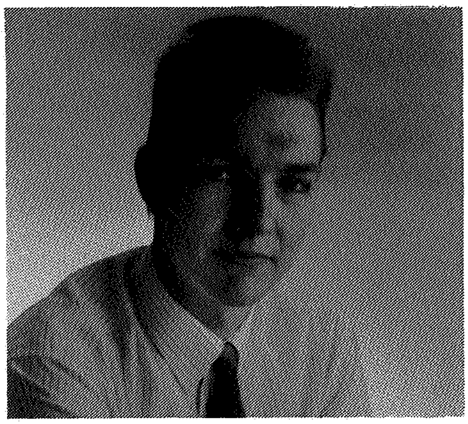
By means of the studies collected in this report it can be shown that there are hardly any investigations into naturally ventilated buildings, which also have a high rate of absenteeism due to illnesses. This might be connected with the fact that arising health problems are normally said to be caused by air conditioning. Sure it would be useful to compare air conditioned buildings which are related to a high number of complaints with buildings that are equally equipped with air conditioning but are free of problems. The studies on which this report is based however mention no building suitable for such a comparison.

Many of the symptoms, e.g. aches, eye problems or headache, cannot be related to air conditioning or ventilation systems. Some of the comparisons show that buildings equipped with full air conditioning have better results than mechanically ventilated buildings. The results presented here generally indicate equal tendencies referring to the rate of symptoms. There is no significant difference between the different countries to be seen. It becomes clear that the procedures of the investigations are highly different. In some of the cases e.g. only questionnaires have been used and there have been no environmental measurements. The multitude of sick buildings which have been investigated up to now however makes it evident that the topic of sick building syndrome is still a matter of immediate interest.

7. References

1. #NO 1506 An office environment - problems and improvements
AUTHOR Hanssen S O., Rodahl E.
BIBINF Indoor Air, Vol.3, Sensory and Hyperreactivity Reactions to Sick Buildings. edited by B.Berglund, T.Lindvall, J.Sundell. Swedish Council for Building Research, Stockholm, 1984. 303-307, 4 figs, 2 tabs, 6 refs, #DATE 00:00:1984 in English AIC bk,
2. #NO 1508 Sick building syndrome
AUTHOR Pickering A C.
BIBINF Indoor Air, Vol.3, Sensory and Hyperreactivity Reactions to Sick Buildings. edited by B.Berglund, T.Lindvall, J.Sundell. Swedish Council for Building Research, Stockholm, 1984. 321-325, 3 tabs, 2 refs, #DATE 00:00:1984 in English AIC bk
3. #NO 1510 Case study of a sick building
AUTHOR Waller R A
BIBINF Indoor Air, Vol.3, Sensory and Hyperreactivity Reactions to Sick Buildings. edited by B.Berglund, T.Lindvall, J.Sundell. Swedish Council for Building Research, Stockholm, 1984. 349-353, 1 tab, #DATE 00:00:1984 in English AIC bk,
4. #NO 1730 Condensation prevention: loft ventilation - a discussion paper.
AUTHOR Greater London Council
BIBINF GLC Bulletin 144, Item 4 (Committee date 10/84). Building Technical File, January 1985, No 8, p25-29. 5 figs, 2 tabs, 10 refs. #DATE 00:01:1985 in English
5. #NO 1919 Comparison of health problems related to work and environmental measurements in two office buildings with different ventilation systems.
AUTHOR Robertson A S, Burge P S, Hedge A, et al.
BIBINF British Medical Journal, 10 August 1985, Vol 291. p373-376. 2 tabs, 20 refs. #DATE 10:08:1985 in English
6. #NO 1968 Sick buildings: case studies of tight building syndrome and indoor air quality investigations in modern office buildings.
AUTHOR Sterling E M, McIntyre E D, Collett C W et al.
BIBINF Environmental Health Review, September 1985, Vol 29, No 3, p11-19. 1 fig, 9 tabs, 12 refs. #DATE 00:09:1985 in English
7. #NO 2405 The sick building syndrome : prevalence studies
AUTHOR Finnegan M J, Pickering C A C, Burge P S
BIBINF British Medical Journal, Vol 289, No 4458, 8 December 1984, p1573-1575, tabs,refs. #DATE 08:12:1984 in English
8. #NO 2896 Building illness in a large office complex.
AUTHOR Mc Donald J C
BIBINF in: Indoor air quality in cold climates: hazards and abatement measures. APCA Specialty Conference 1986, p7- 22, 9 tabs, 12 refs. #DATE 00:00:1986 in English
9. #NO 3262 The 'sick' building syndrome in the office environment: the Danish Town Hall study.
AUTHOR Skov P, Valbjorn O, DISG
BIBINF Environment International, Vol 13, 1987, pp339-349, 2 figs, 9 tabs, 21 refs. #DATE 00:00:1987 in English
10. #NO 4036 Sick building syndrome traced to excessive total suspended particulates (TSP).
AUTHOR Armstrong C W, Sherertz P C, Llewellyn G C
BIBINF in: The human equation: health and comfort, proceedings IAQ 89, pp3-7, 2 tabs, refs. #DATE 00:00:1989 in English
11. #NO 4227 Prevalence of health and comfort complaints of office workers: male and female differences.
AUTHOR Kleven S R, Sterling T D
BIBINF in: The human equation: health and comfort proceedings IAQ 89, pp232-236, 5 tabs, refs. #DATE 00:00:1989 in English
12. #NO 4398 An investigation of the relationship between microbial and particulate indoor air pollution and the sick building syndrome.
AUTHOR Harrison J, Pickering CAC, Faragher E B, Austwick P K C
BIBINF Canada, Indoor Air '90, Proceedings of the 5th International Conference on Indoor Air Quality and Climate, Toronto, 29 July - 3 August 1990, Volume 1 "Human Health, Comfort and Performance", pp 149-154. #DATE 00:07:1990 in English
13. #NO 4404 Sick leave due to work-related health complaints among office workers in the Netherlands.
AUTHOR Preller L, Zweers T, Brunekreef B, Boleij J S M
BIBINF Canada, Indoor Air '90, Proceedings of the 5th International Conference on Indoor Air Quality and Climate, Toronto, 29 July - 3 August 1990, Volume 1 "Human Health, Comfort and Performance", pp 227-230. #DATE 00:07:1990 in English
14. #NO 4467 An indoor air quality survey of twenty-six Swiss office buildings.
AUTHOR Turner S, Binnie P W H
BIBINF Canada, Indoor Air '90, Proceedings of the 5th International Conference on Indoor Air Quality and Climate, Toronto, 29 July - 3 August 1990, Volume 4 "Building and System Assessments and Solutions", pp 27-32. #DATE 00:07:1990 in English
15. #NO 5215 Mechanical ventilation in office buildings and the sick building syndrome. An experimental and epidemiological study.
AUTHOR Jaakkola J J K, Heinonen O P, Seppanen O
BIBINF Denmark, Copenhagen, Indoor Air, No 2, 1991, pp 111- 121, 2 figs, 5 tabs, refs. #DATE 00:00:1991 in English
16. Peter Kröling
[1] Gesundheits- und Befindensstrungen in klimatisierten Gebäuden. Vergleichende Untersuchungen zum "building illness"-Syndrom. Copyright 1985 by W. Zuckschwerdt Verlag GmbH, Kronwinkler Strasse 24, D-8000 München 60. Printed in Germany by Stelz- Druck München. ISBN 3-88603-147-0, in German.
17. A London Hazards Centre Handbook
Sick Building Syndrome - Causes, effects and control.
Published by the London Hazards Centre Trust Limited, June 1990, ISBN 0-948974-06-0, in English.

AIVC Staff News



New member of staff

Malcolm Orme joined the AIVC last October, following a short time at the AIVC as a student during which he completed a project on multizone air flow modelling. A graduate in mathematics from the University of Warwick, UK, he will be working on the continued development of the AIVC's numerical database.

Announcement & Call for Papers

Second International Conference on IAQ, Ventilation and Energy Conservation in Buildings 10-12 May, 1995, Montreal, Canada

The ways buildings are designed, constructed, maintained and operated have a direct impact on occupants' health, thermal comfort and productivity as well as on buildings energy consumption.

This conference will be the second in the series entitled "IAQ, Ventilation and Energy Conservation in Buildings". The first meeting was held in 1992, and has gathered industrial and scientific experts, government officials, engineers and architects from around the world to share their knowledge on these important subjects. The objectives of this conference are the provision of a forum for the presentation and discussion of the most recent developments and advances in the field of indoor air quality, ventilation, energy conservation and especially integrated approaches to these three aspects.

The official languages of the Conference will be English and French. Simultaneous translation services in both French and English will be available.

Abstracts of approximately 500 words proposing papers in the above or related topics are invited. Abstracts should be submitted by June 1st, 1994. Notification of acceptance will be forwarded by September 1st, 1994, when the authors will also be advised on the recommended format for the preparation of manuscripts. To ensure the proceedings are available at the time of the conference, authors must return completed manuscripts by December 1, 1994 for review and final selection.

Abstracts should be sent to:

Dr Fariborz Haghighat
Centre for Building Studies
Concordia University
1455 de Maisonneuve Blvd W
Montreal, Quebec H3G 1M8
Canada

Tel: (514) 848 3192
Fax: (514) 848 7965

Forthcoming Conferences

Indoor Air '93 The 6th International Conference on Indoor Air Quality and Climate
4-8 July 1993
VENUE: Helsinki, Finland
CONTACT: Indoor Air '93, PO Box 87, SF-02151 Espoo, Finland, Fax: +358 0 451 3611

International Buildings Performance Simulation Association
Third International Conference
Building Simulation '93
VENUE: Adelaide, Australia
CONTACT: IBSPA Conference Secretariat, Satour Promotions, PO Box 44, Rundle Mall, Adelaide, Australia 5000, Tel: +61 8 232 3422, Fax: +61 8 232 3424

Energy Impact of Ventilation and Air Infiltration
14th Annual AIVC Conference
21-24 September 1993
VENUE: Copenhagen, Denmark
CONTACT: Air Infiltration and Ventilation Centre, University of Warwick Science Park, Sovereign Court, Sir William Lyons Road, Coventry CV4 7EZ, Great Britain, Tel: +44 203 692050, Fax: +44 203 416306

ASTM
Symposium on Air Flow Through Building Envelopes
10 October 1993
VENUE: Fort Worth, Texas, USA
CONTACT: Dorothy Savini, Symposia Operations, ASTM, 1916 Race Street, Philadelphia PA 19103-1187, USA, Tel: 215 299 5413

IAI
International Conference
Volatile Organic Compounds
27-28 October 1993
VENUE: Royal College of Physicians, London, UK
CONTACT: Conference Secretariat, International VOC Conference, Unit 179, 2 Old Brompton Road, London SW7 3DQ, UK, Tel: +44 767 318 474, Fax: +44 767 313 929

3rd fold (insert in Flap A)

1st fold

Air Infiltration and Ventilation Centre
University of Warwick Science Park
Barclays Venture Centre
Sir William Lyons Road
Coventry CV4 7EZ
Great Britain

2nd fold (Flap A)

AIVC Publications Order Form

Name.. Date...

Address (including country)..

....

....

Telephone/Fax.../...

Periodicals	P	NP
[ ] Air Infiltration Review	Free	Free
[ ] Recent Additions to AIRBASE	Free	N/A

Guides and Handbooks	P	NP
[ ] Calculation Techniques Guide	Free*	£50*
[ ] Measurement Techniques Guide	Free	N/A
[ ] Handbook*	£10	£10

Conference Proceedings	P	NP
[ ] 10th	£30	£30
[ ] 11th	£35	£35
[ ] 12th	£50	£50
[ ] 13th	£50	£50
[ ]		
[ ]		

Comments

Your comments about AIR are welcome. Please send any comments with your order form.

Technical Notes

	P	NP		P	NP		P	NP		P	NP
[ ] TN5.1	Free	£7.50	[ ] TN17	Free	£20	[ ] 28.2	Free	N/A	[ ] TN37	Free	N/A
[ ] TN5.2	Free*	£7.50*	[ ] TN20	Free*	£20*	[ ] TN29	£15	£25	[ ] TN38	Free	N/A
[ ] TN5.3	Free*	£10*	[ ] TN21	Free*	N/A	[ ] TN30	Free	N/A	[ ] TN39	Free	N/A
[ ] TN5.4	Free	£10	[ ] TN23	£15	£25	[ ] TN31	Free*	N/A*	[ ] TN40	Free	N/A
[ ] TN10	Free*	£15*	[ ] TN24	Free	Free	[ ] TN32	Free	N/A	[ ] TN41	Free	N/A
[ ] TN11	Free*	£15*	[ ] TN25	Free	Free	[ ] TN33	Free	N/A			
[ ] TN13	Free	£20	[ ] TN26	£15	£25	[ ] TN34	£15	£25			
[ ] 13.1	Free*	Free*	[ ] TN27	Free	N/A	[ ] TN35	Free	N/A			
[ ] TN16	Free*	£20*	[ ] TN28	Free	N/A	[ ] TN36	Free	N/A			

IEA Information

[ ] IEA News

[ ] Publications List

Literature Lists - No.s:

I enclose a cheque drawn on a UK bank, and made payable to Oscar Faber Partnership / Please invoice me / Please debit my Master/Visa card (delete as appropriate) for the sum of: £...

Signed..Master/Visa Card No.. Expiry Date ....

* These Technical Notes are available for purchase in microfiche form, or on loan only. Please state if loan preferred.[ ]

KEY: P Participating countries, NP Non Participating countries, mf Microfiche, All prices are in UK pounds Sterling

AIVC Publications

Pricing details for these publications are shown on the order form.

PERIODICALS

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

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

GUIDES AND HANDBOOKS

Applications Guide 1 (1986) Liddament, M.W. 'Air Infiltration Calculation Techniques - An Applications Guide'

Applications Guide 2 (1988) Charlesworth, P.S. 'Air Exchange Rate and Airtightness Measurement Techniques - An Application Guide'

Handbook (1983) Elmroth, A. Levin, P. 'Air infiltration control in housing. A guide to international practice.'

TECHNICAL NOTES

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

TN 10 (1983) Liddament, M,, Thompson, C. 'Techniques and instrumentation for the measurement of air infiltration in buildings - a brief review and annotated bibliography'

TN 11 (1983) Liddament, M., Allen, C. 'The validation and comparison of mathematical models of air infiltration'

TN 13 (1984) Allen,C. 'Wind pressure data requirements for air infiltration calculations'

TN 13.1 (1984) '1984 Wind Pressure Workshop Proceedings'.

TN 16 (1985) Allen,C. 'Leakage Distribution in Buildings'

TN 17 (1985) Parfitt, Y. 'Ventilation Strategy - A Selected Bibliography'

TN 20 (1987) 'Airborne moisture transfer: New Zealand workshop proceedings and bibliographic review'

TN 21 (1987) Liddament, M.W. 'A review and bibliography of ventilation effectiveness - definitions, measurement, design and calculation'

TN 23 (1988) Dubrul,C. 'Inhabitants' behaviour with regard to ventilation.

TN 24 (1988) 'AIVC Measurement Techniques Workshop: Proceedings and Bibliography'

TN 25 (1989) Blacknell,J. 'A subject analysis of the AIVC's bibliographic database - AIRBASE',

TN 26 (1989) Haberda,F and Trepte,L. IEA Annex IX 'Minimum ventilation rates and measures for controlling indoor air quality.

TN 27 (1990) Bassett, M. 'Infiltration and leakage paths in single family houses. A multizone infiltration case study.'

TN 28 (1990) Sutcliffe, H. 'A guide to air change efficiency.'

TN 28.2 (1991) Brouns C, Waters JR, 'A guide to contaminant removal effectiveness'.

TN 29 (1990) Feustel, H E, et al 'Fundamentals of the multizone air flow model - COMIS.'

TN30 (1990) Colthorpe, K 'A review of building airtightness and ventilation standards.'

TN31 (1990) Limb, M 'AIVC's fifth worldwide survey of current research into air infiltration, ventilation and indoor air quality.'

TN32 (1991) Harrje DT, Piggins JT 'Reporting guidelines for the measurement of airflows and related factors in buildings.'

TN33 (1991) Liddament M W 'A review of building air flow simulation.'

TN34 (1991) Roulet C-A, Vandaele L 'Air flow patterns within buildings: measurement techniques.'

TN35 (1992) Knoll B 'Advanced ventilation systems - state of the art and trends.'

TN36 (1992) Limb M J 'Airgloss Air Infiltration Glossary'.'

TN 37 (1992) Liddament M W, 'A Strategy for Future Ventilation Research and Applications',

TN 38 (1992) Limb M J 'AIRGUIDE: Guide to the AIVC's Bibliographic Database'.

TN 39 (1993) Liddament M W "A Review of Ventilation Effeciency".

TN 40 (1993) Kendrick J F, "An Overview of Combined Modelling of Heat Transport and Air Movement".

TN 41 (1993) Wilson D and Walker I, "Infiltration Data from the Alberta Home Heating Research Facility".

AIVC CONFERENCE PROCEEDINGS

AIVC Conference Proceedings nos 1-9 are available as individual papers. Details of contents can be forwarded on request.

10th 'Progress and trends in air infiltration and ventilation research' Espoo, Finland, 1989;

11th'Ventilation System Performance' Belgirate, Italy, 1990;

12th'Air Movement and Ventilation Control within Buildings', Ottawa, Canada, 1991, 3 volumes.;

13th'Ventilation for Energy Efficiency and Optimum Indoor Air Quality', France, 1992;

14th 'Energy Impact of Ventilation and Air Infiltration', Copenhagen, Denmark, September 1993 (to be published soon)

mf Proceedings of AIVC conferences numbers 1-10 are also available in microfiche form.

LITERATURE LISTS

1) Pressurisation - infiltration correlation: 1. Models.
2) Pressurisation - infiltration correlation: 2. Measurements.
3) Weatherstripping windows and doors.
4) Caulks and sealants.
5) Domestic air-to-air heat exchangers.
6) Air infiltration in industrial buildings.
7) Air flow through building entrances.
8) Air infiltration in commercial buildings.
9) Air infiltration in public buildings.
10) Carbon dioxide controlled ventilation.
11) Occupancy effects on air infiltration.
12) Windbreaks and shelterbelts.
13) Air infiltration measurement techniques.
14) Roofs and attics.
15) Identification of air leakage paths.
16) Sick buildings.
17) Flow through large openings.
18) Control of cross contamination from smokers.
19) Location of exhausts and inlets.

*For list of participating countries see back page.

IEA ENERGY CONSERVATION IN BUILDINGS - REPORTS FROM OTHER ANNEXES

IEA Energy Conservation News Six monthly newsletter of the IEAEnergy Conservation in Buildings Programme, contains topical updates on the current projects, and news of conferences, workshops, etc

Publications A list of publications for the various annexes can be provided on request free of charge.

Representatives and Nominated Organisations

Belgium

*P. Wouters, Belgian Building Research Institute (WTCB/CSTC), rue de la Violette,21-23, 1000 Brussels, Belgium. Tel: 02-653-8801 Fax: 02-653-0729

P. Nusgens, Université de Liège, Laboratoire de Physique du Bâtiment, Avenue des Tilleuls 15-D1, B-4000 Liège,Belgium. Tel: +32 41 66 56 74 Fax: +32 41 66 57 00

Canada

*M. Riley, Buildings Group, Energy Efficiency Division, Efficiency and Alternative Energy Branch, Energy, Mines and Resources Canada, Ottawa, Ontario, K1A 0E4 Canada Tel: 613-996-8151 Telex: 0533117 Fax: 613-996-9416

J. Shaw, Inst. for Research in Construction, National Research Council, Ottawa, Ontario, Canada K1A 0R6 Tel: 613-993-1421 Telex: 0533145 Fax: 613 954 3733

T. Hamlin, Research Division, Canada Mortgage and Housing Corporation, Montreal Road, National Office, Ottawa, Ontario, Canada K1A 0P7 Tel: 613-748-2984 Telex: 052/3674 Fax: 613 748 6192

Denmark

*O. Jensen, Danish Building Research Institute, P.O. Box 119, DK 2970 Hørsholm, Denmark. Tel: 45-42-865533 Fax: 45-42-867535

P.F. Collet, Technological Institute, Byggeteknik, Post Box 141, Gregersensvej, DK 2639 Tastrup, Denmark. Tel: 42-996611 Telex: 33416 Fax: 45-42-995436

Finland

*M Luoma, Technical Research Centre of Finland, Laboratory of Heating and Ventilation, Lämpömiehenkuja 3, PO Box 206, SF-02151 Espoo 15, Finland. Tel: 358-0-4561 Telex: 122972 Fax: 358-0-4552408

France

*P Hérant, ADEME, Route des Lucioles, 06565 Valbonne Cedex, France Tel: 33 93 95 79 00 Fax: 33 93 65 31 96

Ph. Duchêne-Marullaz, CSTB, 84 Ave. Jean Jaurès, BP 02 Champs sur Marne, 77421 Marne la Vallée, Cedex 2, France Tel: (33-1) 64 68 83 13 Fax: (33-1) 64 68 83 50

Germany

*Prof. Dr.-Ing. F. Steimle, Fachinstitut Gebäude-Klima, Danziger Strasse 20, 7120 Bietigheim-Bissingen, Germany Tel: 071 42/54498 Fax: 071 42/61298 Telex: 7264754 fgk

J. Gehrmann, Projektträger Biologie, Energie, Okologie in der KFA Jülich GmbH, Postfach 1913, D-5170, Jülich, Germany Tel: 02461/614852

G Mertz, Fachinstitut Gebäude Klima, Danziger Strasse 20, 7120 Bietigheim-Bissingen, Germany Tel: (49) 7142 54598 Fax: (49) 7142 61298

Italy

*M. Masoero, Dipartimento di Energetica, Politecnico di Torino, C.so Duca delgi Abruzzi 24, 10129 Torino, Italy. Tel: (39-11) 564 4441 Telex: 220646 POLITO Fax: 39 11 564 4499

Netherlands

*W.F. de Gids, TNO Building and Construction Research, Dept of Indoor Environment, Building Physics and Systems, P.O. Box 29, 2600 AA Delft, Netherlands, Tel: +31 15 608608 (Direct: +31 15-608472) Fax: +31 15-608432

New Zealand

*M. Bassett, Building Research Association of New Zealand Inc (BRANZ), Private Bag, Porirua, New Zealand. Tel: 64-4-2357600 Fax: 64 4 2356070

Norway

*J.T. Brunsell, Norwegian Building Research Institute, Forskningsveien 3b, PO Box 123, Blindern, N-0314 Oslo, Norway. Tel: +47 22-96-55-46 Fax: +47-22-699438

H.M. Mathisen, SINTEF,Division of App Thermodynamics, N-7034 Trondheim, Norway. Tel: 07-593870 Telex: 056-55620

Sweden

*J. Kronvall, Technergo AB, Ideon, S-223 70 Lund, Sweden, Tel: +46 46 16 88 81, Fax: +46 46 16 88 80

J Lagerström, Swedish Council for Building Research, Sankt Goransgatan 66, S-112 33, Stockholm, Sweden Tel: 08-6177300 Fax: 08-537462

Switzerland

*V. Dorer, EMPA, Section 175, Ueberlandstrasse, CH 8600 Dübendorf, Switzerland. Tel: 01-823-4789 Telex: 825345 Fax: 01-821-6244

UK

S. Irving (Operating Agent), Oscar Faber Consulting Engineers, Marlborough House, Upper Marlborough Road, St. Albans, Herts, AL1 3UT, Great Britain. Tel: +44(0)81-7845784 Telex: 889072 Fax: +44(0)81-7845700

*MDAES Perera, Environmental Systems Division, Building Research Establishment, Garston, Watford, WD2 7JR , UK Tel: +44(0)923 664486 Telex: 923220 Fax: +44(0)923 664010

M. Trim, Building Research Energy Conservation Support Unit (BRECSU), Building Research Establishment, Bucknalls Lane, Garston, Watford, Herts, WD2 7JR, Great Britain. Tel: +44(0)923 894040 Telex: 923220 Fax: (0)923-664010

P.J.J. Jackman, BSRIA, Old Bracknell Lane West, Bracknell, Berks, RG12 4AH, Great Britain. Tel: (0)344-426511 Telex: 848288

USA

*M. Sherman, Indoor Air Quality Division, Building 90, Room 3074, Lawrence Berkeley Laboratory, Berkeley, California 94720, USA. Tel: 510/486-4022 Telex: 910-366-2037 Fax: 510 486 5172 e-mail:MHSherman@lbl.gov

A. Persily, Building Environment Division, Center for Building Technology, Building 226, Room A313, National Institute for Standards and Technology, Gaithersburg MD 20899, USA. Tel: 301/975-6418 Fax: 301/975-4032

J. Talbott, Department of Energy, Buildings Division, Mail Stop Ce-131, 1000 Independence Avenue S.W., Washington D.C. 20585, USA. Tel: 202/586 9445 Telex: 710 822 0176 Fax: 202 586 4529/8134

*Steering Group Member

AIVC

Head of Centre Martin W Liddament

Published by
Air Infiltration and Ventilation Centre
University of Warwick Science Park
Sovereign Court
Sir William Lyons Road
Coventry CV4 7EZ, UK

Tel: +44(0)203 692050
Fax: +44(0)203 416306

Operating agent for IEA is Oscar Faber Consulting Engineers, UK