Air Infiltration Review

a quarterly newsletter from the IEA Air Infiltration and Ventilation Centre

International Energy Agency - AIVC

Vol. 14, No. 1, December 1992

AIVC 13th Conference - Keynote Speech

The Main Aspects of Research Conducted in France in the Field of Ventilation and Indoor Air Quality

by Pierre Hérant and Marie-Claude Lemaire
ADEME, Sophia Antipolis, France

Before presenting the French position in the field of ventilation and indoor air quality, we find below a presentation of the ADEME, (Environment and Energy Management Agency), along with some general notes on the building sector in France.

L'Agence de l'Environnement et de la Maîtrise de l'Energie

To clearly situate the work of the ADEME in the field of indoor air quality, a field which encompasses our concern for the environment and energy efficiency, it would seem appropriate to make a brief presentation of the Agence Française de l'Environnement et de la Maîtrise de l'Energie (ADEME).

This Agency is a public organisation which was established at the beginning of 1992 incorporating the Agence Française pour la Maîtrise d l'Energie (French Agency for Energy Management), l'Agence Nationale pour la Récupération des Déchets (National Agency for Recovery and Elimination of Waste) and l'Agence pour la Qualité de l'Air (Agency for the Quality of Air).

Its aim is to conciliate economic and social development with a rational use of natural resources and the harmonious integration of man in his environment.

Its purpose is to instigate, animate, coordinate, facilitate and when necessary, carry out any operation in order to:

- Conserve energy and raw materials;
- Promote new technology and alternative energy sources;
- Limit the production, eliminate, recover and valorize waste;

In this issue

- Prevent pollution and protect the air quality;
- Fight noise pollution;
- Prevent ground pollution.

In total, the Agency's staff numbers six hundred spread over four sites (Angers, Paris, La Défense, Sophia Antipolis) and 26 regional delegations.

The research and technological development program has been structured around three areas of intervention: the planetary area (greenhouse effect, ozone layer, depletion of resources...), the sectorial area (products and processes) and the territorial area (development, flow management, nuisances and localized risks).

The indoor air quality in buildings is affected by two of the areas: territorial and sectorial.

Indeed we are interested by the quality of air in buildings, in particular from the point of view of the effects on health; this can only be studied using an integrated approach: air breathed in the interior of a building compared with air breathed in the course of a day, air and other factors: noise, water, ...

To guarantee good air quality it is necessary to act at industrial sector levels: products and ventilation systems, materials used in the buildings, domestic products,...

Some Key Figures on the Building Sector in France

In 1991, the residential and tertiary sector consumed 79,3 million TOE or 44% of the total consumption of final energy. 66% of this consumption is attributed to 21 million dwellings in the residential sector, the rest being consumed by the tertiary sector (schools, hospitals, offices, shops,...).

The total stock of dwellings is composed of 55% individual houses and 45% of collective dwellings, 38% were built before 1948, 37% between 1948 and 1975 and 25% after 1975.

The energy consumption for heating and hot water production in a new dwelling built to present thermal regulations has been reduced by more than 50% compared with 1974. At the same time the share of energy consumed for the purpose of air change has gone from 10% to 30%.

Aeration systems in dwellings have always been directly linked to the regulations in force. It is therefore possible to note a few important dates:

1937: generalisation of air vent installation;
1958: possibility of air extraction via vertical ducting;
1968: generalisation of permanent overall ventilation;
1982: possibility to regulate flow rate of extracted air;

1983: possibility of automatically regulate air flow rate.

At present, about 30% of dwellings do not have a ventilation system.

The indicative breakdown of the aeration systems market for new dwellings is as follows:

	Air Extraction		Collective	Individual
General and permanent aeration	Mechanical	Traditional	70%	56%
		Hygro controlled	15%	6%
		Heat exchanged	5%	2%
	Natural		10%	22%
Permanent aeration limited to certain rooms	Mechanical and/or natural		0%	14%

It is also appropriate to note that the cost of a ventilation system is very small in relation to the global cost of construction which explains why ventilation is not always given the attention it warrants.

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.

Concerning the tertiary sector, the aeration depends upon many parameters such as the use for which the building was intended, the date of construction, etc.

Approximately 5% of surface area is air conditioned.

The Evolution of Requirements Relative to Ventilation

Effective ventilation depends upon three considerations:

- to satisfy the requirements of hygiene and comfort of the occupants.
- to ensure the conservation of the building.
- to allow the secure operation of all combustion appliances on the premises, connected or otherwise.

From a regulation viewpoint, in order to satisfy these requirements the ventilation systems are designed according to the principle of generalised and permanent aeration of dwellings with extracted air flow rates imposed.

Today the products and systems must evolve in order to take into account the evolution of the requirements.

- to take account of the actual occupation of the premises.
- to take account of the activities.
- the presence of appliances such as cooker hoods and tumble driers.

- the need to adapt systems to behaviour of occupants (opening of windows).
- possibility for the occupants to operate the system.
- acoustic requirements.
- aesthetic requirements.

Energy Efficiency and Air Quality

The economies of energy (in particular the reduction of rates of ventilation, but also the use of certain insulating materials) have often been accused as the source of all ills.

- by the doctors for whom mechanical ventilation and air conditioning is seen in a bad light.
- by sectors of the Building Trade for whom an increase in the rate of air change is the universal solution to all problems.

Today, we have at our disposal elements (1) (2) (3) (4) (5) which allow us to state that energy efficiency and indoor air quality are not contradictory.

Air quality is primarily a problem of source. It is therefore necessary above all to limit emissions and then select an appropriate treatment.

In certain cases the increase of air extraction flow rates results in a reduction of overall efficiency. (3)

Certain pollutants such as cat allergens are seen to be higher in concentration for a higher rate of air change. (5)

Studies have shown that when an air quality problem is detected, in more than half the cases, it is attributable to the ventilation. The cause of the problems generally lies with the design, application or operation of the system.

What is at Stake?

The stakes are the demands of quality of interior atmosphere which lead us to install energy consuming equipment having an impact on the environment.

Optimisation of technical solutions to better deal with demands will have a significant impact on energy consumption, quality of the environment, health and productivity of the occupants. This, incidentally, corresponds to sectors of a large market.

Energy

Energy consumption linked to air change is of high level. We have seen earlier that energy conservation and interior air quality are not incompatible. However, at present, according to existing regulations, the requirements for air quality are frequently expressed in quantities of new air without prejudging the efficiency of the systems. To improve the indoor air quality, it might be tempting for the legislator to increase the ventilation flow rate: this would not produce the desired effect and would bring about unnecessary over consumption.

Environment

Today we spend approximately 90% of our time indoors. To concern ourselves with indoor atmosphere quality is to concern ourselves with the quality of our everyday environment. The use of new materials, of new construction techniques, the evolution of domestic products, etc should encourage us towards greater vigilance.

The environment, in the planetary sense of the term is equally concerned in so much as all energy consumption is accompanied by pollutant by-products.

Although it is difficult to calculate what is at stake, the impact on health due to interior atmosphere quality, and in particular the quality of the air, is uncontested.

To situate the stakes we can note that health expenditure in France amounted to 560 billion francs (100 billion US$) in 1989 or 26,000 francs (5,000 US$) per household. Oxycarbon intoxications are the cause of 400 deaths and 8000 hospitalizations every year: smoking, asbestos, radon, etc have an undeniable influence on public health.

Studies and Research in Progress

After having worked in an independent manner for many years the building professions and health professions are learning to work together.

We can cite, amongst recent achievements:

- The GEVRA (Ventilation and Air Change Study Group)

This group was set up in 1986 at the instigation of the French Agency for Energy Management (AFME) to coordinate the work being done in the field of ventilation and air change. It now comprises research teams involved with the subject and the public bodies concernced: ADEME, ANAH, EdF, GdF, PCA. Every two years a seminar is held to take stock of the state of progress (1) (2) (3).

Today eleven research laboratories are involved: CEBTP, CSTB, CETIAT, INSA-CETHIL, EdF, ENTPE, GdF, INRS, LET Poitiers, LNE, CETE.

These groups have at their disposal powerful research tools such as wind tunnels and test cells: rooms or apartments full size or scaled down.

These tools allow the capture of the physical phenomena and the adjustment of the standard calculations to simulate the comportment of dwellings relative to air change. Developments in this field are conducted in direct liaison with the IEA.

In addition, specific tools have been developed to qualify air change and air permeability of buildings.

These studies lead us to a better understanding of reality, in particular:

- air permeability in buildings,
- the behaviour of different types of ventilation and particularly that of hygro-controlled systems,
- the behaviour of occupants (relative to windows, ventilation systems),
- the origin of observed disorders.

These elements enable us to direct the research and technical developments, to adapt the communication.

- Invitation to tender 1991: Ventilation Systems and Components for Dwellings

As indicated earlier, the regulations in force do not allow for the best answers to the demands of the user, in particular concerning odours, air quality and humidity extraction. So it appeared opportune to invite tenders with the aim of bringing to light the most effective ventilation systems and components in the thermic, sanitary and olfactory areas, conforming to a better consideration of the users needs.

This invitation to tender jointly coordinated by the AFME and the PCA received 17 replies from industrialists, most of whom associated with various partners including technical centres and research laboratories.

The panel of experts selected ten proposals. The results of these studies should be available within two years. Without revealing the exact content of these proposals, some major tendencies can be noted:

- multifunction air inlets,
- assisted natural ventilation,
- individualization of mechanically controlled ventilation.

- Air quality comfort and health in housing: A study by the CEBTP-EdF-GdF

To ensure good indoor air quality in dwellings is one of the essential functions of ventilation.

Given the complexity of the development of heating and ventilation products integral to these requirements, the EdF, GdF and the FNB (Fédération Nationale du Bâtiment) have combined their respective know-how and resources of calculation and experimentation, with a view to evolving a set of demanding specifications for heating and ventilation providing a better compromise between atmospheric comfort, health, and energy efficiency.

This important programme is sponsored by the PCA (Construction and Architecture Plan) of the Ministry of Housing and the ADEME.

This joint action is organized around 3 poles:

- the accomplishment of a national survey,
- clarification and validation of an effective calculation code,
- editing of an exacting specification list.

The objective of the enquiry is to pinpoint the present areas of dissatisfaction and the wishes of users in the areas of comfort and health in housing.

It has been carried out using a questionnaire divided into 3 sections:

- a technical section which describes in as much detail as possible, the characteristics of the dwelling, heating and ventilation systems, appliances and materials present inside.
- a sociological section intended for the study of the manner in which the occupants of the dwelling behave relative to their interior environment and to the use of appliances.
- a medical section intended on the one hand to reveal the possible disturbances to the health of the occupants, due to concentration of pollutants and the prevailing climatic conditions inside the dwelling, and on the other hand, to discover the interaction between the perception of comfort and morbidity stated by the occupants.

564 dwellings were subjected to the survey with a total of 1765 occupants.

- Air Quality in air conditioned premises: Study by CETIAT-IUMTE-DP3M

At the request of the EdF, GdF, the Ministry of Research and the AFME, the Aeraulic and Thermic Industries Technical Centre (CETIAT) combined with the University Institute of Occupational Medicine and Ergonomics of Grenoble (IUMTE) and with the Department of Medical amd Molecular Parasitology Mycology of Grenoble (DP3M) to carry out a study of the air quality in air conditioned premises with the aim of improving the design, use and maintenance of air conditioning equipment in order to optimise air quality and energy consumption.

This study comprises 4 phases:

Phase 1: study of the aerobiometrology

Phase 2: study of equipment in hospital and in an office building

Phase 3: editing of a guide to the design, use and maintenance of air conditioning equipment

Phase 4: pilot scheme

The first phase was indispensable (how can we understand phenomena that we do not know how to measure?) and revealed the necessity for more thorough study. The second phase is in progress.

- Development of passive detectors - LABORATOIRE NATIONAL D'ESSAIS

Wishful for a discreet and easy-to-install device to define indoor air change, the ADEME commissioned a study of the development of passive detectors by the L.N.E. (Laboratoire National d'Essais).

The objective is twofold; one, to make use of this tool in research, two, to make it available to professionals who all too often neglect the air change question.

The passive detector technique was developed in the USA.

Its immediate use in France is subject to certain limitations (delivery, cost). Owing to the availability of the technology and considering the competence of the L.N.E. in the field of gas analysis, the finished article will be more accurate and will possess a wider range of functions - (temperature, hygrometry, Volatile Organic Elements).

The actions previously presented are the principal research studies in progress. For a more exhaustive overview refer to the Bibliography (1) (2) (3) (4) (5) (6).

Prospects

Our objective is to improve indoor atmospheric air qualities while concurrently optimising energy consumption and minimising the impact on the environment.

To achieve this, our needs can be classified in the following manner:

- Define the requirements:

The threshold values of the W.H.O. (World Health Organisation), where they exist, do not appear sufficient. Epidemiological studies are necessary, we must make sure that the parameters relative to buildings are fully considered.

Air quality is a problem of pollutants (sources). These sources may originate from the exterior: atmospheric pollution, ground, water; or interior: connected with the building and construction materials, to the fixtures and fittings, to the use of the premises, to the activity of its occupants.

As a general rule, interior pollution is greater than exterior pollution.

It is important to properly examine the emissions in order, in the first instance, to act directly at source, and secondly, to adapt the strategy to the problem; one does not apply the same strategy to problems as diverse as radon, tobacco smoke, a disconnected water heater, or intermittent human occupation.

- Improve our knowledge of the phenomena:

Pollutant transfer, diffusion, absorption-desorption by materials, reactivity,...

- Research and develop appropriate solutions

- Finalise a method of audit

- Communicate:

We have noticed that the concepts of aeration-ventilation are not fully appreciated by users and some professionals with consequent disorders which could be avoided.

Although there is a lot yet to learn, we already have at our disposal information to impart.

Today, it would appear evident that this type of study must be conducted in a manner consistent with that being carried out at an international level. The majority of French study groups are already involved in these programmes.

Bibliography

1. AFME - Seminaire de Contractants Ventilation et Renouvellement de l'Air dans l'Habitat - Sophia Antipolis - 17-18 Novembre 1987
2. AFME - Seminaire Specialisé Ventilation et Renouvellement d'Air - Sophia Antipolis - 19-20 Septembre 1989
3. AFME Seminaire Specialisé Ventilation et Renouvellement d'Air - Lyon - 21-22 Mars 1991
4. Ministere de l'Environnement - Plan Construction et Architecture, Qualité de l'Air Intérieur des Locaux Habitables - Recontre Interchercheurs - 8 Octobre 1991
5. Societé Française d'Aerobiologie - Seminaire Controle de la Qualité de l'Air - 24-25 Janvier 1992
6. Ministère de l'Environnement - Plan Construction et Architecture, Confort et Santé dans les Locaux Habitables - Rencontre Interchercheurs - 4 Juin 1992

13th AIVC Conference, Hotel Plaza Concorde, Nice, France

Ventilation for Energy Efficiency and Optimum Indoor Air Quality

Conference Report by John Kendrick, AIVC

The Thirteenth Annual Air Infiltration and Ventilation Centre Conference opened with a welcome to the 93 delegates from thirteen countries, from Dr. Martin Liddament, the Head of the Centre. Martin introduced the chairman of the opening session Mr. Steve Irving, the operating agent of the AIVC. Opening the conference the keynote speaker Mr. Pierre Hérant of ADEME, France, discussed the current research in France covering the subjects included in this conference. ADEME is a public body formed in 1992 to study the integration of man into the environment, the conservation of energy and raw materials, the prevention of pollution, and the maintenance of air quality. Future work within France will be to improve IAQ, to study energy impacts, and improve knowledge on the action of pollution. Research and development in these areas will be focused in the future on a national and international scale, the AIVC conference being an ideal platform for this kind of International cooperation.

Steve then introduced the first session on large building case studies and numerical prediction techniques. Mike Holmes and Fiona Cousins of Ove Arup, UK, jointly presented a paper on the optimisation of the thermal and ventilation performance of naturally ventilated building facades. This presentation was followed by Don Dickson from EA Technology in the UK, with a paper studying the indoor air quality and comfort features of a modern building in Northern England. As a result of various surveys it was discovered that the most common occupant complaint is the lack of privacy and the noise levels in open plan offices.

Controlled background ventilation for large commercial buildings was the title of the next presentation from Earle Perera of the Building Research Establishment in the UK. Earle showed that the assessment of the building characteristics of UK buildings is difficult, and asked the question whether trickle ventilation systems were sufficient for the ventilation of an industrial building in the winter. This plenary session continued with Andrew Persily of the National Institute of Standards and Technology, USA, who presented a paper based on the proposed guidelines on ventilation and building characterisation for indoor air quality investigations. Andy described a series of check lists covering four main areas: Whole buildings; test spaces; HVAC serving the space; and the performance measurement of the HVAC system. The check lists described in the paper will be published in the near future.

Alois Schälin from the Laboratory for Energy Systems in Switzerland described a method for modelling the air and contaminant conditions within a building using a combined multi zone and computational fluid dynamics (CFD) approach. The multi zone model is used to calculate the thermal boundary conditions for the CFD code as well as approximate flow paths. Results from the CFD code can then be fed into the multi zone code until the results are consistent. To complete this first session Jacques Riberon of CSTB, France presented a paper on the subject of modelling fluctuating air flow through large openings. Fluctuating air flow patterns are caused by changes in wind pressures and can be classified in two ways: pulsating or eddy flow. Then Jacques compared his calculated results with information gathered from a test house on the French Atlantic coast.

The second plenary session was concerned with ventilation and heat recovery and was chaired by Viktor Dorer of EMPA, Switzerland. This session commenced with a paper from Professor Fritz Steimle of the University of Essen, Germany, on the potential for heat recovery in ventilation systems. He stressed that the principal aim of all this work should be the saving of energy at the primary source.

To continue the energy theme, Robin Wiltshire of the University of Westminster, UK, explained the research presently being carried out in the assessment of sun spaces combined with heat recovery ventilation for two test houses. Robin included the results from the analysis of a variety of cases using thermal and CFD models for the thermal appraisal and ideal positioning of any glazing. A new energy efficient office building in Finland was the subject of the next paper from Juhani Laine of Finland. Total energy costs for the building were very low and the self controlling heating system only needed to be adjusted on the coldest days, ie -15° C.

William Rose, University of Illinois, USA, continued the theme of heat exchangers with a description of an efficient enthalpy exchanger for economical ventilation. William noted that in the USA, air conditioning is no longer regarded as a luxury, so the development of energy efficient systems is essential. This particular exchanger is based on a folded membrane, the potential contamination of which will be investigated later in the study with smoke tests. Karl-Joseph Albers followed, presenting a paper on the results of his research work at the University of Dortmund, Germany on the energy savings by balanced ventilation with heat recovery and a ground heat exchanger. The combination of the heat recovery unit and heat exchanger could account for 35% of the heat for the family under investigation. Professor Frank Dehli of FGK in Germany completed the session with a paper describing the prospects for energy recovery in ventilation systems. Professor Dehli had calculated that energy recovery systems in Europe could save an estimated 5 billion DM each year.

Session three consisted of a series of five minute oral presentations chaired by Dr. Max Sherman of Lawrence Berkeley Laboratory in the USA. These short presentations were followed by the authors displaying posters of their work in the conference room, allowing the delegates to discuss the displays. The posters covered a wide range of subjects including: natural ventilation for cooling, the efficiency of cooker hoods, ventilation requirements for buildings, and CO_2 reduction.

Conference poster session chaired by Max Sherman

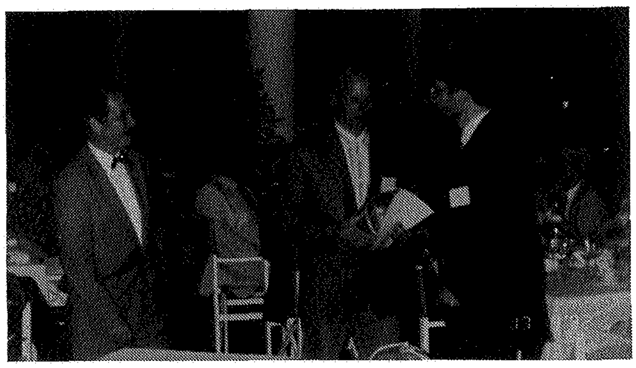
The fourth session of the conference, chaired by Professor Fritz Steimle of Germany was opened with a presentation from Johnny Kronvall of Technergo in Lund, Sweden, on behalf of the paper's author Ake Blomsterberg. Johnny talked about the problems associated with the natural ventilation of various houses, and the characteristics of the ventilation systems in these dwellings. This was followed by Mr. Alain Grelat of CEBTP, France with the results from the application of the computer program BILGA to investigate any correlation between carbon dioxide concentrations and condensation hazards in dwellings, making it possible to control ventilation on the basis of a single criteria and to examine various ventilation strategies.

Maria Kolokotroni of the University of Westminster continued the session with a presentation of a case study approach to the measurement of airborne moisture movement in occupied dwellings. The authors discovered that the moisture levels within occupied areas could be reduced using extract fans, particularly the bathroom and kitchen areas. Christian Nicholas of Electricité de France showed the results of a survey by Bernard Fleury on the measurement of window opening in dwellings. It was concluded that an occupant's perception of total window opening was underestimated compared to sensor measurements. Max Sherman presented a paper on behalf of Marco Modera and his colleagues at LBL, on indoor ozone concentrations and their ventilation rate impacts and the mechanisms of outdoor concentration attenuation. To conclude the session Martin Liddament, of the Air Infiltration and Ventilation Centre gave a brief presentation of the latest technical note from the Centre, which outlines a strategy for future ventilation and the resultant energy effects. All of these strategies are motivated by the energy use in buildings.

Maria Kolokotroni receives prize for best paper presentation from Mr Della Porta

The second poster display session was chaired by Dr. Earle Perera of the Building Research Establishment in the UK. Posters displayed included: the penetration of gaseous pollutants into buildings in the case of sudden contamination of the outdoor air, an air flow pattern reference book; ATLAS- a reference book of computed flow fields as a result of Annex 20; and the investigation of the potential use of thermography for building air leakage characteristics.

At the evening banquet, the award for the best written paper was presented to Maria Kolokotroni from the UK with 'Airborne Moisture Movement in Occupied Buildings: A Case Study Approach'. The prize for the best poster display went to Kai Sirén of the Helsinki University of Technology with a presentation titled 'The Penetration of Gaseous Pollutants into Buildings in the Case of Sudden Contamination of the Outdoor Air'.



Kai Sirén is congratulated by Martin Liddament for winning the award for best poster

The final plenary session of the conference was chaired by Willem de Gids of TNO in the Netherlands, covering a variety of measurement studies. Jacques Riberon of CSTB, France started the session with a description of the actual performances of ventilation systems in buildings. The procedure involved two methods of testing, using the existing equipment within the building, or a lightweight compact fan system. This was followed by Johnny Kronvall of Sweden with a paper on the correction of tracer gas measurement results for climatic factors, he emphasised the need for an extrapolation technique to apply standard measurements for any possible weather conditions. Dr. Bob Waters of Coventry University followed by presenting the findings of a recent investigation into the ventilation of a large scale industrial building. The research centred around the assessment of the air handling devices in a specific area of the factory that created problems with the health of the employees.

Bjarne Olesen of Virginia State University, USA continued the measurement theme with a presentation of the problems associated with the use of tracer gases in multi zoned buildings. In particular Bjarne remarked that the positioning of the source and sampling points is critical, and the subsequent interpretation of the data can be difficult. Finally the results of measuring and predicting the dispersal of gases within a naturally ventilated kitchen was presented by Gianni Fracastoro of the Polytechnic of Turin, Italy. Gianni compared the results of measurements with computational fluid dynamics predictions to demonstrate the effects of natural ventilation on the dispersal of gases from an oven.

To complete the conference, Peter Jackman from BSRIA in the United Kingdom, presented a summing up of the six sessions. Peter commented on the fine content of the papers and the high standard of presentation, and how encouraging it was to see so many papers written as a result of international cooperation. He noted that over 50% of the papers were concerned with dwellings and there were relatively few papers on other buildings. There were the same number of presentations on modelling as measurement. Peter then demonstrated his idea of the ideal energy efficient office and dwelling, as a result of the papers presented throughout the conference. He reminded the audience of the high level of complexity and growing sophistication in the work being carried out to minimise energy losses in buildings. Peter stressed the need for integration of all these techniques, and that it is essential that these tools are available to the designer. He then asked the question whether buildings are net filters or net polluters. Peter thanked the authors for the good mix of papers and hoped to see everyone in Denmark for the fourteenth conference in September 1993.

International Energy Agency

Air Infiltration and Ventilation Centre's 14th Annual Conference

Energy Impact of Ventilation and Air Infiltration

Copenhagen, Denmark, 21st to 24th September 1993

First Announcement and Call for Papers

The purpose of the AIVC's 14th Annual Conference is to address the energy issues associated with ventilation and air infiltration.

Topics include:

- Assessing the energy impact of ventilation and air infiltration (including the results of national studies and evaluating energy impact according to building type).
- Methods to assess energy impact (i.e. measurement and computational techniques).
- Energy reduction through heat recovery.
- Demand controlled ventilation.
- System energy demand.
- The identification of ventilation needs.
- Alternative indoor air quality control measures (e.g. pollutant elimination, dehumidifiers, filtration, etc.)
- The influence of air infiltration on ventilation performance.
- Ventilation to meet cooling needs.
- Dealing with outside pollutants.
- Case studies and examples.

Abstracts of approximately 300 words in length are invited of proposed papers. These should be sent to Rhona Vickers at the AIVC by 5th February 1993. Abstracts will be reviewed in March 1993 and accepted papers will be required by 31st July 1993.

The conference will take the form of formal presentations and poster displays with author introcuctions. Authors should indicate their preference but final choice will be determined at review. Proposals from non AIVC countries are welcome.

Please forward abstracts to: Mrs Rhona Vickers, Air Infiltration and Ventilation Centre, University of Warwick Science Park, Sovereign Court, Sir William Lyons Road, Coventry CV4 7EZ, Great Britain

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

13th AIVC Conference

"Ventilation for Energy Efficiency and Optimum Indoor Air Quality"

Award Winning Poster Presentation

The Penetration of Gaseous Pollutants into Buildings in the Case of a Sudden Contamination of the Outdoor Air

by K E Sirén
Helsinki University of Technology, Espoo, Finland

Synopsis

A sudden contamination of the outdoor air by toxic gas can have several causes. The primary goal of the investigation was to determine the protection afforded by sheltering indoors. The object of a computational approach was a single family house with two floors. Three different models were utilized as computing tools: MOVECOMP to calculate the infiltration air flows, MULTIC to calculate the temperature decay using the two-dimensional distribution of the outdoor air temperature and wind speed, and a statistical approach. The results show the cumulative distribution functions of the relative doses inside the building for different tightness levels, exposure times and other relevant parameters.

1. Introduction

A sudden contamination of the outdoor air can be caused by a transportation accident, a sudden emission from an industrial plant, a disaster in a nuclear power plant or even by traffic. The envelope of a building can be utilized as a shelter against the contaminated outdoor air. The protection afforded by sheltering indoors depends primarily on the tightness of the building envelope, the outdoor air temperature and the wind speed. Other parameters, like the leakage distribution, the pressure coefficients, the wind direction and the local environment around the building, have some influence too. However, the problems involved in sheltering have not been investigated very much [1...3] and there is a shortage of useful quantitative knowledge.

The most reliable way to look into the penetration of contaminated air into a building would be to use tracer gas measurements. This would, however, be a very laborious, time consuming and expensive way, and if the effect of the building tightness and the weather statistics were also to be investigated, the amount of work would be enormous. A better way, not as reliable but much more flexible, is to approach the problem using computer models.

2. The Building

The object of the computational examination is a single family house with two floors and a steep ridge roof. It is not a real, existing building, rather an imaginary one to be used as input data for the calculations. It does, however, represent a common type of house and its leakage characteristics can be fixed on certain levels for calculation purposes. Both floors have five rooms and the floors are connected by stairs. The total floor area of the living space is 140 m^2. No description of the ventilation ductwork is included because it is assumed that in an emergency situation the ventilation is cut off and the ducts are sealed.

For the air infiltration calculations 80% of the envelope leakage area was distributed proportional to the length of the joints. The remaining 20% was placed in the floor and the ceiling to represent pipe and duct passages. The cracks in the building shell had a flow exponent value of 0.65 [4,5,6]. Four different airtightness levels were used for the whole building. The n_{50} value varied from 1 l/h to 15 l/h, while the distribution of the leakage area and the flow coefficients remained unchanged. The flow coefficients for each level were adjusted using a computational 50 Pa pressurization. The pressure coefficients of the building facades were in situ measured values [7].

For the contaminant transport calculations the building was divided into ten zones. Each room was one zone. The indoor air temperatures of the zones were simply chosen according to the experience gained from measurements in similar situations [8,9]. The temperature difference between adjacent zones, which is the crucial parameter from the viewpoint of the circulating air flows through the open doors and thus the contaminant transport, was chosen to be 0.1 °C. The mean indoor air temperature was 21.0 °C.

3. Computing Tools

To calculate the infiltration, exfiltration and internal net air flows, the multizone simulation program MOVECOMP [10] was used. The input data contains a description of the leakage characteristics of the building, the pressure coefficients, the indoor and outdoor air temperatures and the wind speed. The mass balance equations of the system nodes are the basis of the solution, as an output the mass flow rates through the flow paths and the pressures of the nodes are given.

The concentration histories and doses in various zones inside the building were calculated using a computer code MULTIC [11] developed especially for this purpose. The calculation is based on the conservation of mass of the contaminant in the zones. The mixing of the contaminant in each zone is assumed to be complete and instantaneous. The circulating air flows between adjacent zones are calculated using a simple analytical procedure [12]. Some validation of the code has been done [8.9] and it shows that generally the results are satisfactory and the performance of the program can be considered sufficient for the purpose.

4. Weather Data

The most important weather parameters affecting the pressure distribution and the infiltration and exfiltration flows of a building are the outdoor air temperature and the wind speed and direction. The mean two-dimensional frequency distributions of the temperature and the speed values measured in Finland during the years 1961-1980 [13] were used as input data for the calculations. The wind speed was reduced with a coefficient of 0.5 [4, 14] to take the effect of the terrain into account.

5. Concepts

The relevant quantity from the health point of view is the dose, which is the integral of concentration over time. The concentrations and the doses in different zones grow at different speeds. The mean dose in the building is defined as the arithmetic mean of the doses in all zones. Further, the concentrations and doses depend on the concentration level outside. Dividing the indoor dose by the outdoor dose gives the relative dose, which does not depend on the outdoor concentration level. Performing both the operations gives the relative mean dose at the moment t:

$$<D^*(t)> = \frac{\frac{1}{N}\sum_{i=1}^{N}[\int_0^t C_i(t')\,dt']}{\int_0^t C_{out}(t')dt'} \qquad (1)$$

where N is the number of zones in the building, $C_i(t)$ is the concentration in zone i at moment t, t' is a dummy variable of integration and $C_{out}(t)$ is the outdoor concentration. This relative mean dose is a very central quantity in the presentation of the computed results.

The two-dimensional frequency distribution of the outdoor temperature and wind speed, which was used as input data, contains approximately 200 pairs of values for a one-year period. To be able to present the results of the calculations in a compact form, a statistical approach has to be utilized. The cumulative frequency of the computed relative mean dose values $F(<D^*(t)>)$ is the quantity used in this context.

6. Results

An example of the cumulative frequencies of the relative mean dose is presented in Fig 1. Here the location by which the weather data is determined is Helsinki, Finland. The period for the weather data is one year. All inner doors are wide open. Four different levels of air tightness and five different exposure times t = 1h, 3h, 6h, 12h and 24h were used. The cumulative frequency can be interpreted as the probability when the relative mean dose does not exceed the value on the abscissa. If the period is not one year but e.g. January, the frequency curves shift to the right because the temperature difference between indoors and outdoors is larger.

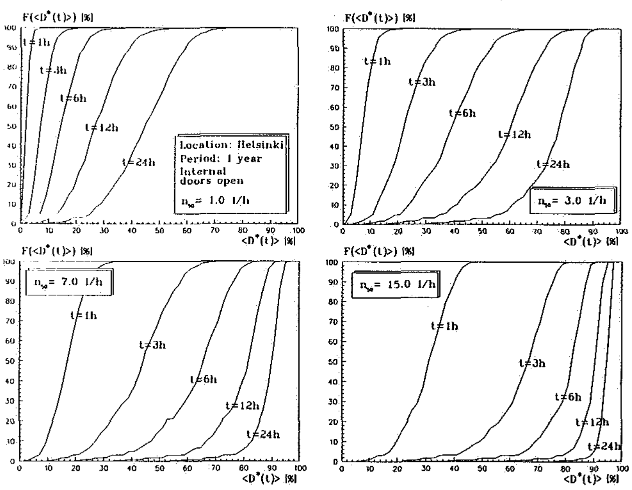


Figure 1: The cumulative frequencies of the relative mean dose.

The occupants, when sheltering indoors, should try to minimize the dose by moving into the zone where the lowest concentration occurs. Here, besides the outdoor air temperature and wind speed, the direction of the wind and the status of the inner doors are also of importance. The tightness of the building, on the other hand, does not play an important role in this context. Fig 2 gives an example of the location of the minimum dose values after 12 hours' exposure. A more thorough presentation of the results is given in the reference [15].

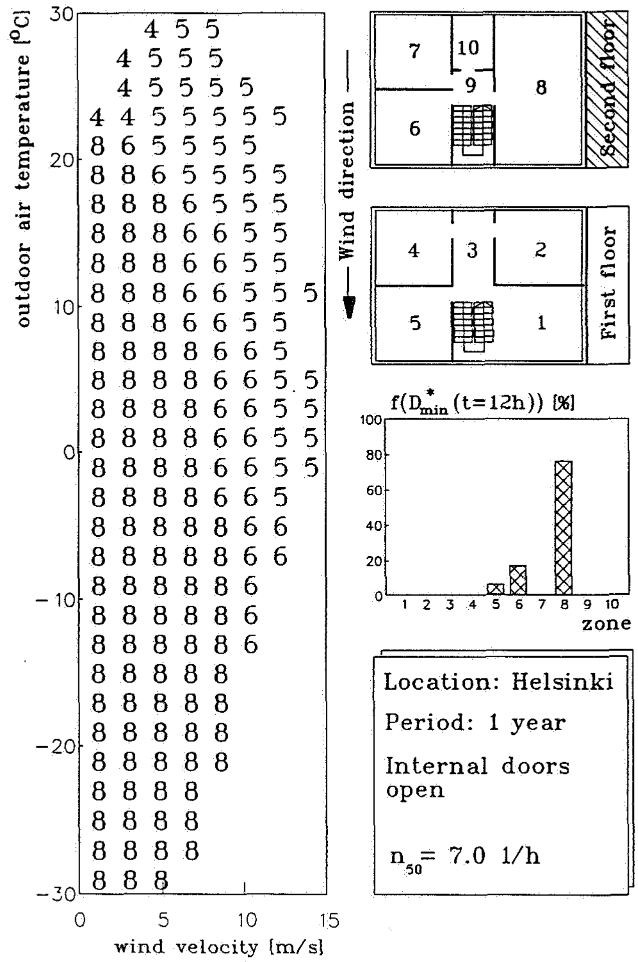


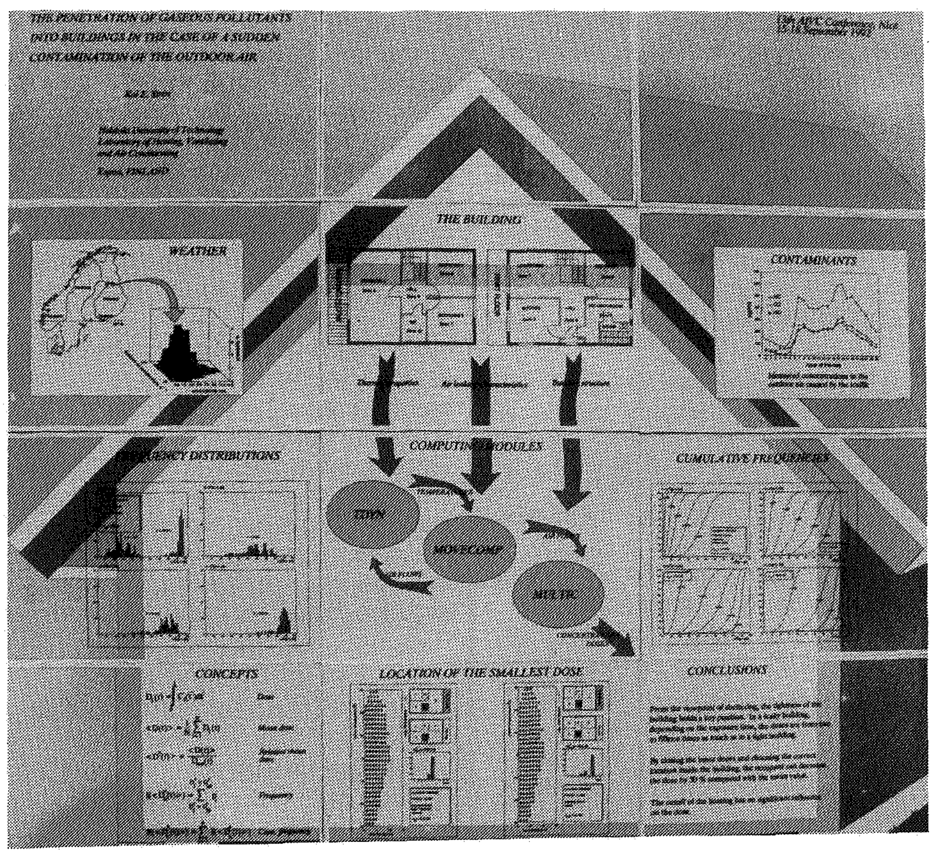
Figure 2: The location of the minimum dose, an example.

7. Conclusions

From the viewpoint of sheltering, the tightness of the building holds a key position. In a leaky building, depending on the exposure time, the doses are from two to fifteen times as much as in a tight building. By closing the inner doors and choosing the correct location inside the building, the occupant can decrease the dose in favourable conditions by 50% compared with the mean value. This does, however, require knowledge of the local wind direction.

References

1. Nylund P O, Spread of gas in buildings exposed to poisonous outdoor air. ASHRAE Transactions 93, Part 1, 1394-1407, 1987.
2. Trepte L, Ventilation strategies in the case of polluted outdoor situations. The Proceedings of the 9th AIVC Conference, Gent, Belgium, 63-79, 1988.
3. Wilson D J, Zelt B W, The influence of non-linear human response to toxic gases on the protection afforded by sheltering-in-place. OECD/UNEP Workshop on Emergency Preparedness and Response, Boston, Massachusetts, May 7-10, 1990.
4. Liddament M W, Air infiltration calculation techniques - an applications guide. Air Infiltration and Ventilation Centre, 1986.
5. Gustén J, Wind pressures on low-rise buildings. Chalmers University of Technology, Division of Structural Design, Publication 1989:2, Gothenburg 1989.
6. Blomsterberg Å, Ventilation and airtightness in low-rise residential buildings. Swedish Council for Building Research, Document D10:1990, Stockholm 1990.
7. Luoma M, Marjamäki P, The pressure coefficients of the test houses. Technical Research Centre of Finland, Research report 691, Espoo 1987. (In Finnish with English abstract).
8. Sirén K E, A procedure for calculating concentration histories in dwellings. Building and Environment 23, No 2, 103-114, 1988.
9. Sirén K E, The estimation of concentration histories in dwellings in unsteady conditions. Roomvent '90, International Conference in Oslo, June 13-15, 1990.
10. Herrlin M, A multizone infiltration and ventilation simulation program. Air Infiltration Review 9, No3, 305, 1988.
11. Sirén K, A computer program to calculate the concentration histories and some air quality related quantities in a multi-chamber system. Helsinki University of Technology, Institute of Energy Engineering, Report 18, Espoo 1986.
12. Sirén K, The mixing of air between adjacent rooms in dwellings. Papers of Room Vent 87, Session 4b, Stockholm, Sweden, 10-12 June 1987.
13. Heino R, Hellsten E, Climatological statistics in Finland 1961-1980. The Finnish Meteorological Institute, Supplement to the meteorological yearbook of Finland 80, part 1a, 1980.
14. ASHRAE Handbook of Fundamentals 1989, Chapter 14, Airflow around buildings.
15. Sirén K, A computational approach to the penetration of gaseous pollutants into building, part I: single family house. Helsinki University of Technology, Institute of Energy Engineering, Report 45, Espoo 1992.



Airborne Moisture Movement in Occupied Dwellings. A Case-Study Approach

M Kolokotroni, N Saiz and J Littler

Research in Building Group, University of Westminster, London, UK

Abstract

This paper reports the results of humidity and ventilation measurements in occupied residential buildings to study the effect of airborne moisture movement on condensation risks. The dwellings have been fitted with a cooker hood and an extractor fan (both with variable speed control) in the kitchen, and an extractor fan in the bathroom. The investigation of each case-study included monitoring the temperature and humidity at four locations in the house for a number of weeks during the heating season in order to examine the water vapour cycle in each room as affected by moisture production in the space and moisture migration from adjacent rooms and outside. Detailed short time measurements have also been taken to study the effect on the humidity in one room, of water produced in other rooms, and the efficiency of the variable flow-rate extract devices for the local removal of moisture before it becomes well mixed.

In this way the efficiency of each ventilation device, in isolation and in combination with the others, in removing moisture from the rooms in which it is produced, has been examined, as well as its effect in reducing the rate of moisture migration to the rest of the house. It has been possible to find relationships between the moisture loads in the rooms in each case-study thus describing the effects of interzonal moisture flows in situations typical of those found in dwellings at risk of condensation.

1. Introduction

Water vapour is one of the internal environmental contaminants which is rarely mentioned when discussing air quality. However, although it might not affect people in the same dramatic manner as CO_2, NO_x, O_3 and HCHO, it is present in a large proportion of buildings, mainly residential, it is transported in a similar manner [1] and it is impossible to eliminate its sources. High relative humidity can cause structural deterioration and is connected to human illness such as asthma and allergies due to dust mites [2-5]. Excessive humidity can create condensation, mould problems and discomfort; but low humidity can cause its own problems. Apart from discomfort due to dehydration of the skin and mucous membranes, some bacteria and viruses like lower humidities [6]. Therefore, humidity extremes need to be avoided, with an optimum zone in the middle of the relative humidity scale.

A high percentage of the residential building stock suffers from the effects of excessive moisture. According to the latest English Housing Survey [7] more than half of UK households are affected with problems ranging from condensation on windows to mould on walls and furniture. The problem is also present in other cold countries such as Canada where results of a survey in 1991 indicated that 39% of the people had at least one moisture or mould indication in their homes [8]. The problem appears to be more acute in new housing where low ventilation levels coupled with cold bridges have increased the problem [9].

It is only the last 30 or so years that there is evidence that air movement is very important in moisture migration in the same way as water vapour diffusion through the fabric of the buildings [10]. Only recently the importance of ventilation in removing moisture at source has been emphasised in the Building Regulations [11] and publications on methods of avoiding condensation and evaluating the risks have appeared [12] including international efforts aimed at providing solutions to the problem [13].

Increased ventilation seems to be the solution in most cases. The effectiveness of extractor fans and cooker hoods in reducing the migration of moisture to other spaces of the dwellings is the subject of this paper. Three small homes were investigated before and after the installation of extract devices and it was found that excess vapour pressure (internal vapour pressure above outside vapour pressure) has been reduced in source rooms (kitchens and bathrooms) and also in sink rooms (living rooms and bedrooms).

2. Description of the Case-Studies

The floor plans of the three case studies are presented in Fig. 1.

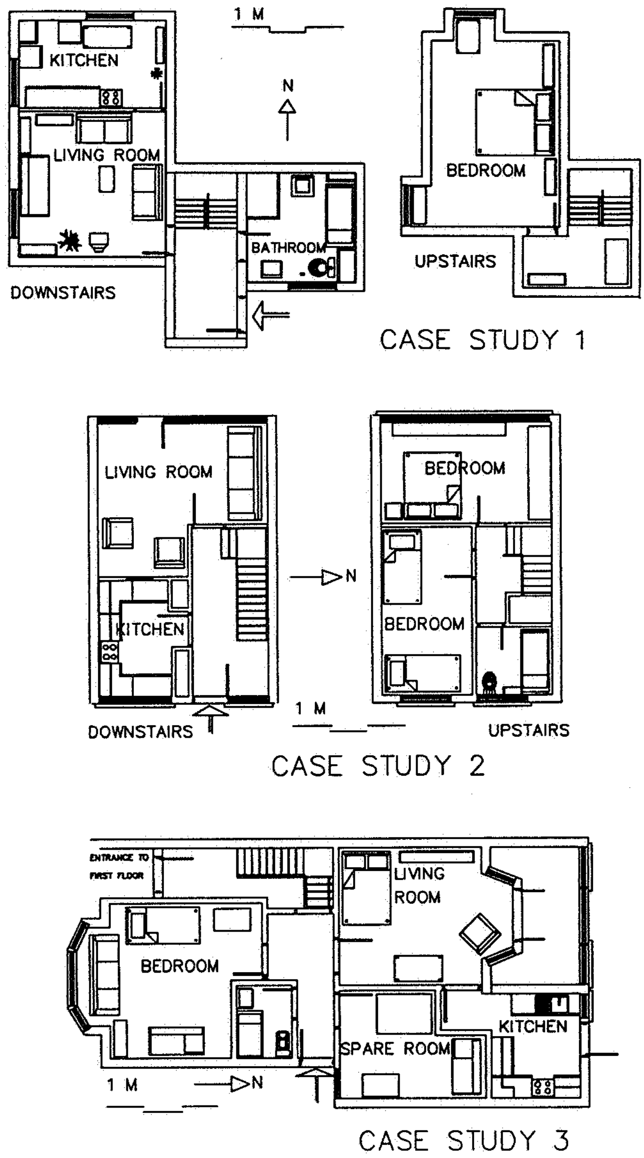


Figure 1: Floor plans of the three case studies

The first case study is a maisonette in East London, a region of low cost housing with most of the housing stock built after World War Two. Two adults live in the flat, which comprises a kitchen, living room and bathroom on one floor and a bedroom on another, with a total floor area of approximately 65 m^2. The maisonette is situated on the two upper floors of a five storey block of flats containing 70 housing units. There is no thermal insulation in the brick walls or the roof and the windows are timber frames and singly glazed. Heating is provided by a time-controlled gas boiler (located in the kitchen) and radiators in every room apart form the bathroom which is heated with an electric wall mounted radiant bar. Ventilation is provided by sash windows, window vents (which were all blocked by the occupants) and vents into a bricked-up chimney in the living room.

The second case study is a 60s maisonette in South London in a council owned block of flats. Two adults occupy the flat which comprises a kitchen and living room downstairs and a bathroom and two bedrooms upstairs with a total floor area of 60 m^2. The maisonette occupies the two upper floors of a four storey building containing 55 housing units. The walls are not thermally insulated and the windows are steel framed, singly glazed. However, plastic double glazed windows have been recently installed in the bedroom windows, following complaints about condensation and draughts. Heating is provided by an open gas fire in the living room and an electric heater situated at the top of the staircase. The only ventilation means is through the openable windows.

The last case study is a converted end of terrace ground floor flat also in South London. A single parent with a child lives in the flat which consists of a kitchen, bathroom, living room, bedroom and spare room, all on one floor covering a total area of 70 m^2. The brick walls are uninsulated with single glazed timber framed openable windows for natural ventilation. Heating is provided by a time controlled gas boiler (located in the kitchen) with radiators in every room of the flat.

For the purpose of this study, all three dwellings were fitted with extract devices in the kitchen and bathroom in order to evaluate their effectiveness at removing moisture in source rooms and in preventing moisture migration to sink rooms. In the kitchen a window mounted extractor fan was installed with a maximum flow rate of 78.6 l/s equipped with variable speed controller. In addition a cooker hood was installed and ducted outside, with a maximum flow rate of 28 l/s. In the bathroom the humidistat controlled extractor fan has a maximum flow rate of 28 l/s. In all cases, they comply with the 1990 UK Building Regulations [11].

3. Monitoring the Humidity and Temperature

The temperature and relative humidity were monitored for a minimum period of one week before the installation of the ventilation equipment and at least one week after, by placing thermohygrographs in the main rooms of each house, i.e., kitchen, bathroom, living room and one bedroom. The data is used to characterise the basic climate of the houses; that is, temperatures, mixing zones, basic flow paths and occupant use/interference.

The aim is to examine whether there is a reduction in the excess vapour pressure not only in the moisture source rooms (kitchen and bathrooms) but also in the moisture sink rooms (living room and bedroom). The assumption is that the only different parameter (apart from the external conditions) affecting the internal moisture balance before and after the installation of the fans is the way that they are used.

An example of the vapour pressure outside and four locations in the first case study under normal occupation and fan operation regime is shown in Fig 2. Vapour pressure is significantly higher indoors than outdoors indicating the effect of interior moisture production and restricted ventilation as is usually the case in the majority of homes in winter. Vapour pressure is the highest in the unheated bathroom (equipped with a humidistat controlled extractor fan), followed by the kitchen, living room and bedroom. Although, the vapour pressure in the living room and bedroom are similar, temperatures in the bedroom are lower than in the downstairs living room, so that the relative humidity is much higher upstairs, thus creating more condensation problems. As expected, there is a loose correlation with external humidities apart from the times that high and sudden moisture production indoors alters the internal patterns.

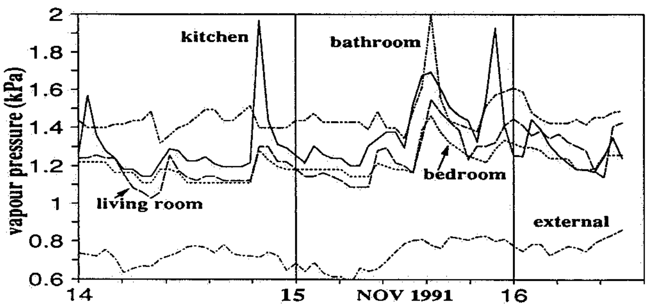


Figure 2: Typical plot of vapour pressure indoors and outdoors

Figure 2 also presents data for two subsequent days during which the home was used in a different manner. During the first day cooking for dinner was the only source of moisture (apart from metabolic activities) while in the second day, cooking for lunch and dinner, bathing and laundry were performed. This has resulted in elevated vapour pressure in all the rooms for longer time during the second day.

It is evident that moisture produced in the kitchen or the bathroom has an effect on the vapour pressure in the living room and bedroom. It seems that the living room is affected more than the bedroom both from moisture migration from the kitchen and the bathroom for this particular house layout. This is a point requiring closer examination because it determines how much the moisture produced in one room affects the moisture in another, and is discussed in Section 4.

Considering the humidity status of the dwellings for the weeks before and after the installation of the extract devices, it was obvious that the mean humidity level has been reduced as a consequence of the combined use of the two extractor fans and cooker hood. An example of this, is shown in Fig 3, where the external and internal relative humidity for the four rooms of Case-Study 1 have been plotted. Similar temperatures were maintained during the "before" and "after" periods due to the thermostat located in the hallway (there is a difference in the living room and in the bedroom of 1 °C but the kitchen and bathroom are almost identical). The relative humidity however has fallen quite considerably in the three rooms (kitchen, living room and bedroom) but not in the bathroom. In this case the low flow rate, humidistat controlled extractor fan, set to 80% RH cut off point, has maintained the RH below 80%. However, it is now apparent that the humidistat was incorrectly set and this has influenced the internal humidity. As a result of less ventilation as the windows are opened less frequently, the excess vapour pressure has increased. The average excess vapour pressure of the three rooms (excluding the bathroom) are presented in Fig 4. The average reduction of mean excess vapour pressure is over 40%, which for an average temperature of 19 °C results in an average RH reduction of more than 10%. The RH in the bathroom has increased by 4% (from an average value of 70% before the installation of the fans to 74% after).

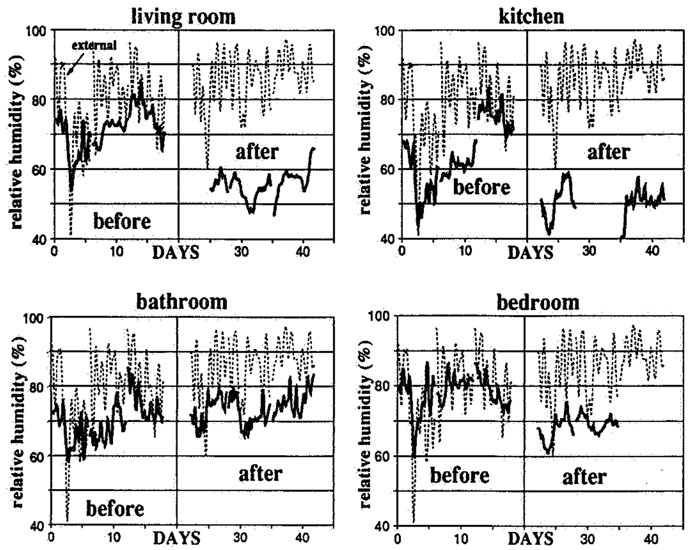


Figure 3: External and internal relative humidity values for the monitored four rooms of Case Study 1. The average external temperature is 9.9 °C before the installation and 7.4 °C after. The internal temperatures are 18.3, 21.3, 18.6 and 16.7 °C in the living room, kitchen, bathroom and bedroom correspondingly before the installation and 19.2, 21.0, 18.3 and 15.4 °C after.

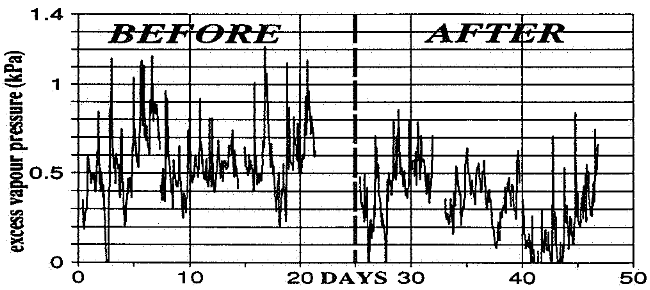


Figure 4: The installation of extract devices in Case Study 1 in normal use, reduced the mean excess vapour pressure in the three of the four rooms

BS5250 [14] classifies households as "dry", "moist" and "wet" occupancy. Dry occupancy (usually a building unoccupied during the day) results in an internal vapour pressure up to 0.3kPa in excess of the external vapour pressure. In moist occupancy water vapour excess is between 0.3kPa and 0.6kPa while in wet occupancy water vapour excess is greater than 0.6kPa. As shown in Table 1, the three households studied, although unoccupied during the day, fall into the moist category.

		Kitchen	Living Room	Bedroom	Bathroom
CASE 1	before	0.68	0.51	0.51	0.52
	after	0.33	0.31	0.38	0.64
	% change	-51	-39	-25	+23
CASE 2	before	0.54	0.22	0.43	0.66
	after	0.51	0.36	0.41	0.45
	% change	-5	+63	-5	-32
CASE 3	before	0.54	0.45	0.53	0.45
	after	0.46	0.34	0.26	0.30
	% change	-15	-24	-51	-33

Table 1: Mean values of excess vapour pressure in the three case studies before and after the installation of extract devices.

In Case Study 1, excess vapour pressure was reduced by 50% in the kitchen, almost 40% in the living room and 25% in the bedroom, bringing the values near the "dry" occupancy category. The reverse has happened in the bathroom, because of the high setting of the humidistat.

In Case Study 2, the results are less dramatic with only 5% reduction in the kitchen and in the bedroom but more than 30% reduction in the bathroom. In this case the volume of the bathroom is smaller than in Case Study 1, and the humidistat was set more reasonably to 70% RH. The operation of the fans has increased the humidity in the living room. This is probably due to the fans in the kitchen and bathroom through which the air is mainly extracted so that infiltration occurs mainly through the living room in the downstairs half of the dwelling. This change of air flow patterns coupled with the higher external vapour pressure during the "fans operating" monitoring period and the low ventilation rate in the living room, has increased the vapour pressure in it.

In Case Study 3, there is also a reduction in the excess internal vapour pressure after the installation of the fans. In this case, the greatest reduction is observed in the bedroom (more than 50% reduction) which is affected by moisture in the kitchen and the bathroom because of the flat's layout.

As nothing has change in the operation of the households after the installation of the ventilation devices, we can assume that the operation of the fans (higher ventilation rates where and when required) has produced the reduction of the excess internal vapour pressure. Also, because moisture is extracted at source rooms at the time it is produced, the effect should be greater than uniformly increasing the ventilation rate at all times. Intermittent ventilation as and when required also eliminates energy waste.

Let us use Case Study 1 as an example to demonstrate this point. The ventilation rate of the dwelling was measured using the tracer gas decay method. It was found the average ventilation is 0.53 AC/H without any extract devices on, while the ventilation rate becomes 0.85 AC/H when the cooker hood is on in the kitchen. The higher ventilation rate happens only for about one hour per day and this has an effect of almost 40% reduction in the average excess vapour pressure of the house. In addition, it may replace opening windows during cooking which would waste more energy without offering the efficiency of a cooker hood.

The discussion of Section 3 was concerned with the steady state performance of the three houses and has shown that reduction of the excess vapour pressure is possible by using extractor fans. This finding agrees with findings of a nationwide survey in UK [15] which concluded that ventilation devices, air movement, heating and insulation are more important than occupants' behaviour and energy consciousness. However, what it has not shown so far is by how much the moisture production in the kitchen and in the bathroom affects the humidity of other rooms and what is the effectiveness of each fan in isolation. For this reason, experiments on cooking and bathing simulations with simultaneous tracer gas release were performed in two of the case-studies (1 and 3) to examine the effect of air flow on the migration of moisture and the effect of adsorption by surfaces.

4. Measurements of Moisture and Air Flow

It has been found [16] that if adsorption and condensation are ignored, water vapour behaves very similarly to tracer gases. Therefore, if a way of accounting for absorption and condensation were found, tracer gases, could be used to predict airborne moisture movement in buildings. For this reason, as well as to understand the relation between the layout of a dwelling and the effect of adsorption in the migration of moisture from source to sink rooms, the following experimental procedure was set up.

Periods of cooking and bathing were simulated and the spread of two contaminants (water vapour and sulphur hexafluoride) from a hot source to various rooms was measured. To simulate cooking the contaminants were released for 25 minutes from the cooker's hot plate. In this experiment 1.46 litres of water was boiled and 2500 ml of tracer gas was released. To simulate bathing the contaminants were released for 11.5 mins, from the middle of the bath (total amounts released 0.62 l of water and 1150 ml tracer gas). The concentrations were measured with a Bruel & Kjaer photo-acoustic effect gas analyser which pumped samples of air from each room via an automated manifold, measuring one room in two minutes. Nineteen experiments were performed in each dwelling to include different settings of the fans.

The Transfer Index (TI) [17] in each room was calculated for the moisture and sulphur hexafluoride. The average Transfer Index of all the rooms in any experiment represents the total contaminant load of the house, thus indicating the effectiveness of a specific fan for a specific flow rate for a particular plan configuration. Figures 5 and 6 demonstrate the removal effectiveness of the fans examined in the two flats.

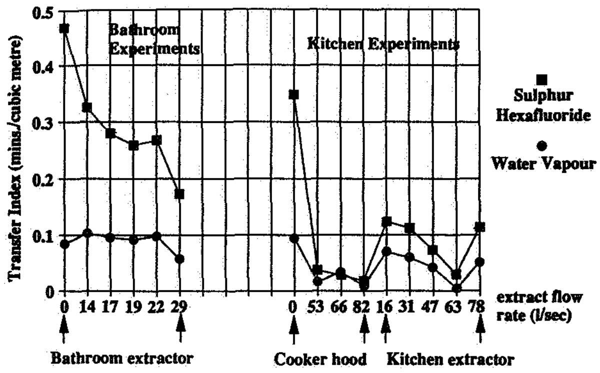


Figure 5: Effectiveness of the extract systems judged by the effect in the whole dwelling of Case Study 1.

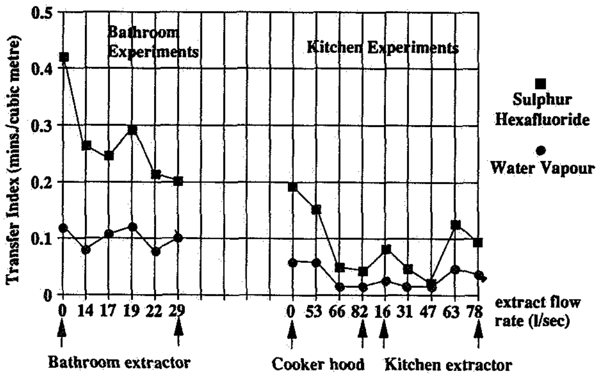


Figure 6: Effectiveness of the extract systems judged by the effect in the whole dwelling of Case Study 3.

It can be seen from the figures that during the bathroom experiments the air becomes saturated and the fan proved to be underpowered in removing the moisture even at its boost position (291 l/s) in both flats. Therefore, no comparison can be easily made with the tracer gas behaviour. However, it can be seen that the flow rate recommended by the Building Regulations for intermittent powered extraction in bathrooms (15 l/s) is an underestimate.

In the kitchen experiments almost straightforward comparisons between moisture and tracer gas removal are possible. In Case Study 1 the cooker hood at all settings proved to be more effective than the extractor fan. In Case Study 3, however, the cooker hood and the fan seem to be almost equally effective. This introduces another dimension into the problem. In Case Study 3 the fan is situated nearer to the cooking hob than in Case Study 1. Therefore, the proximity of the source and removal at source appear to be important.

So far the average TI of the dwellings as a whole was considered. By examining the TI of each room separately, we can begin to understand the impedance of pathways for the pollutant migration between zones. The degree of linkage reflects the adjacency of the rooms and configuration of the building plan. The linkages for the two case studies are presented in Table 2. It can be seen from Table 2 that moisture absorption by surfaces is considerable, resulting in much lower TI values for moisture than for the tracer gas. However a strong correlation between the TI of tracer gas and moisture exists; r=0.993 for case study 1 and r=0.994 for case study 3. This indicates the suitability of tracer gas to describe airborne moisture movement between spaces.

		Kitchen	Living Room	Bedroom	Bathroom
CASE 1					
Cooking-	SF_6	0.155	0.085	0.055	0.061
Experiment	H_2O	0.072	0.037	0.019	0.024
Bathing-	SF_6	0.080	0.131	0.205	0.668
Experiment	H_2O	0.030	0.035	0.073	0.226
CASE 3					
Cooking-	SF_6	0.183	0.067	0.026	0.048
Experiment	H_2O	0.059	0.030	0.013	0.019
Bathing-	SF_6	0.062	0.109	0.159	0.664
Experiment	H_2O	0.038	0.035	0.071	0.233

Table 2: Average linkages between rooms for tracer gas and moisture during cooking and bathing experiments.

In addition, a correlation between the monitored data and short term simulation type experiments of cooking and of bathing was found, indicating that the long term performance of extract devices for each room of a house can be predicted by short term experiments. A correlation of r=0.949 was found in Case Study 1 and r=0.82 for Case Study 3. The correlation with tracer gas measurements is also strong (r=0.95 in case study 1 and r=o.734 in Case Study 3). These results indicate that it might be possible to predict the effect of ventilation devices on moisture by performing short term experiments using either water or tracer gas.

The above correlations were calculated as follows: the steady state change of vapour pressure in each room can be expressed by the ratio of the average excess vapour pressure in each room after the installation of the fans to the average excess vapour pressure before the installation. This value can be compared with the ratio of a room's TI calculated from experiments in which some fans were used to the TI for which no fans were used. It was found that the best relationship exists if the steady state values are correlated with the average of the TI calculated from (a cooking experiment without fans) + (a cooking experiment with the cooker hood on) + (a bathing experiment with the bathroom fan on) divided by the average of a cooking and a bathing experiment with no fans.

5. Conclusions

The effectiveness of extract devices and the merits of user control versus humidistat control, have been discussed before [18, 19] and reviewed [20]. Also the capture efficiency of cooker hoods has been investigated [21, 22]. In this paper the aim was to examine the effect that the installation of "off the shelf" extractor devices has on the humidity in occupied small dwellings.

The use of tracer gas techniques to augment humidity measurements has been investigated before [23, 24], and short term measurements have been made of humidity in kitchens and adjacent rooms [25] and in bathrooms [26]. The uniqueness of the present study is in offering monitored data of moisture before the installation and during normal use of extract devices in occupied dwellings coupled with "laboratory" like experimental measurements of tracer gas and water vapour taken in the same dwellings.

From the monitored data it was found that a reduction of the excess vapour pressure was observed in most rooms of the case-studies after the installation of ventilation equipment. The biggest changes were found in the source rooms (kitchen and bathroom) but considerable changes occurred in the sink rooms (living room and bedroom).

From the experiments the average Transfer Index of the house as well as zone Transfer Indices (for individual rooms) were calculated, which give useful information for the linkage of sink rooms to source rooms and information on the effectiveness of individual extract devices for the particular house configuration. The linkage values depend on the length and shape of the pathway and determine how easily contaminants can migrate. Finally, by comparing tracer gas and water vapour measurements, we can get an impression of the amount of moisture adsorbed by the surfaces and the effect of surface condensation.

It was found that Transfer Indices derived from water vapour measurements describe the steady state performance of the moisture balance in the examined case studies. There is also a strong correlation between the transfer indices calculated from tracer gas and water vapour measurements. The actual values differ considerably. It was found [27] that this is due to adsorption by surfaces and condensation, and not to any other mechanisms of airborne contaminant migration. Therefore, if adsorption and condensation can be accounted for by using some coefficients [28], tracer gas short term experiments in existing houses, or even CFD analysis for proposed design, can be used to predict the long term steady state moisture balance of a dwelling.

6. Acknowledgements

Thanks are due to Xpelair and Airflow Developments for supplying the extract devices fitted in the case-studies and to the owners of the dwellings Mr and Mrs Lemmon, Mr McCallum and Mr McKrith for their cooperation. This project is supported by the Science and Engineering Research Council (SERC) of the UK.

7. References

1. Phaff J C and de Gids W F, Airflow driven contaminants, transport through buildings, Proc "Air Movement & Ventilation Control Within Buildings", 12th AIVC Conference, Ottawa, Canada, pp 123-140, 1991.
2. Seymour J, Science on your doorstep, New Scientist, pp 50-52, 7 Dec 1991.
3. Strachan D P and Sanders C H, Damp housing and childhood asthma; respiratory effects of indoor air temperature and relative humidity, Journal of Epidemiology and Community Health, Vol 43, No 1, pp 7-14, March 1989.
4. Packer C N, Stewart-Brown S and Fowle S E, Housing and health in Worcester, some associations from a lifestyle survey of residents aged 16-64, in Conf "Unhealthy Housing: The Public Health Responses", University of Warwick, Legal Research Institute, 18-20 Dec 1991.
5. Svendsen U G, Olsen O T and Pedersen L N (eds), House dust mites and allergy, Position papers, Danish Society for Allergology, Allergy, Supplement Vol 46, No 11, Munksgaard Copenhagen, 1991.
6. The role and control of humidity in IAQ, Indoor Air Quality Update, Vol 4, No 7, July 1991.
7. English House Condition Survey: 1986, Supplementary (Energy) Report, Chapter 8 Damp and Mould Growth, London, HMSO, 1990.
8. White J, Moisture, Mould and Ventilation, Solplan Review, pp 3-6, April-May 1991.
9. Samuelson I, Mould Problems in New Swedish Building, AIVC Technical Note 20, Airborne Moisture Transfer, New Zealand Workshop, 1987.
10. Trethowen H A, Air, Earth, Water...The Sources of Moisture, AIVC Technical Note 20, Airborne Moisture Transfer: New Zealand Workshop, 1987.
11. The Building Regulations 1985, Part F, Ventilation, HMSO, 1990 Edition.
12. Garrat J and Nowak F, Tackling Condensation, BRE Report, 1991.
13. International Energy Agency, Annex XIV, Condensation and Energy, Vol 1-4, 1991.
14. British Standard 5250, Control of Condensation in Buildings, British Standards Institution, 1989.
15. Raw G and Fox T A, Condensation, Heating and Ventilation in Small Homes, Building Research and Information, Vol 19, No 2, 1991.
16. Kolokotroni M, Saiz N and Littler J, Moisture Movement: A Study Using Tracer Gas Techniques and CFD Modelling, Building Services Engineering Research & Technology, Vol 13(2), pp 113-117, 1992.
17. Brouns C and Waters B, A Guide to Contaminant Removal Effectiveness, AIVC TEchnical Note 28.2, 1991.
18. Boyd D and Cooper P, Domestic Kitchen Extract Fans: Effectiveness in Surface Condensation Prevention, Building and Environment, Vol 24, pp 335-345, 1989.
19. Cornish P, Condensation & Mould Growth, Building Services, p 75, Sep 1984.
20. Parnham P, The effectiveness of Domestic Extract Fans, Proc Unhealthy Housing: The Public Health Response, Warwick University, Dec 1991.
21. Geerinckx B, Wouters P and Vandaele L, Efficiency Measurement of Kitchen Hoods, Air Infiltration Review, Vol 13, No 1, pp 15-17, Dec 1991.
22. Yu Y, Narasaki M, Satoh R and Yamanaka T, Prediction of Capture Efficiency of Kitchen Exhaust System Buoyant Plume From Gas Cooking Stove, Proc "Indoor Air '90" Vol 4, Building and System Assessments and Solutions, pp 497-502, 1990.
23. Oldengarm J, Pernot C and deWit M, Modelling: combined heat, air and moisture transport, Chapter 5 in "Condensation and Energy, Sourcebook" Report Annex CIV, Vol 1, IEA, 1991.
24. Oldengarm J and de Gids W F, Field Experiments on Airborne Moisture Transport, Air Infiltration Review, Vol 12, No 2, pp 8-11, March 1991.
25. Poel A, Vapour Distribution in Dwellings: A Preliminary Study, NCIV Dutch Institute for Social Housing, Contribution to Annex XIV, IEA 1988.
26. Fransson J, Ventilation and Humidity in Bathrooms, in "Air Movement & Ventilation Control Within Buildings", 12th AIVC Conference, pp 173-185, Sep 1991.
27. Kolokotroni M, Saiz N and Littler J, Effects of Air Movement on the Moisture Distribution within a Zone, in "Quality of the Indoor Environment" Lester J N, Perry R and Reynolds G L (Eds), Selper Ltd, pp 179-196, 1992.
28. Jones R H L, Modelling Water Vapour Pressure Conditions in an Enclosed Space, BRE/122/2/1, March 1990.

Stop Press - 5th Jacques Cartier Conference a Success

The 5th Jacques Cartier Conference, "Indoor Air Quality, Ventilation and Energy Conservation in Buildings took place on October 7-9 1992 at the Queen Elizabeth Hotel, Montreal, Canada.

Proceedings of the conference are available for loan from the Air Infiltration and Ventilation Centre, and individual papers will be featured in AIVC "Recent Additions to Airbase and added to the AIVC's bibliographic database and library.

Annex 18: Demand Controlled Ventilating Systems: Sensor Tests

by Per Fahlén, Helena Andersson and Svein Ruud
Published by Swedish National Testing and Research Institute, Boras, Sweden, Rpt 1992:13

A test programme has been designed to evaluate the performance characteristics of sensors for the automatic control of ventilation rates. The test programme consists of two main parts, one being the evaluation of sensor performance in laboratory tests and the other referring to long term characteristics of sensors in actual buildings. Included in the present evaluation are nine different types of humidity sensors, two carbon dioxide sensors and five mixed gas sensors.

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% relative humidity at 20 Deg C. The cross-sensitivity to variations in the ambient temperature and power supply (voltage and frequency) are acceptable and the cross sensitivity to hydrocarbons, carbon dioxide and tobacco smoke is negligible. A plastic strip humidity sensor on the other hand proved unsuitable due to excessive hysteresis and linearity errors.

Carbon dioxide sensors show acceptable performance for control purposes but sensor calibration and/or adjustment may be a time consuming process. These sensors are sensitive to humidity, below a threshold value. The mixed gas sensors show a mixed behaviour. Some react strongly to tobacco smoke, some slightly and one hardly at all. The characteristic curve was determined using a gas cocktail consisting of equal parts of one alifatic hydro carbon (nonane), one aromatic hydro carbon (toluene) and one aldehyde (octanal). Tests were also made with one component at a time but there was little difference in the response to the individual components.

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

Annex 20: Air Flow through Large Openings in Buildings Subtask 2 Technical Report

Edited by J van der Maas
Published by Laboratoire d'Energie Solaire et de Physique du Batiment, Ecole Polytechnique Federale de Lausanne, Switzerland 1992

The work performed in this project was based on a literature review showing the needed experimental work to improve the modeling of both airflow through doors and windows. New studies of interzonal airflow and single sided ventilation at seven laboratories in Europe and Canada, have then been carried out in this project's framework and have led to improved models.

The interzonal air flow research was based on three test rooms and mainly focused on natural convection; the aim was to improve the knowledge and the numerical prediction of heat and mass transfer through doorways. This goal was achieved through a joint research effort which was based on the comparison of experimental results. Moreover, these experimental results have been used to validate a CFD model developed at Concordia University.

The test cell results include validated models to compute the mass flows in large openings assuming either isothermal air volumes or linear temperature profiles in both rooms; the discharge coefficients that have been found from the steady state experiments is about 0.43, in agreement with reference experiments used by ASHRAE but measured under very different circumstances. Local discharge coefficients have also been determined. Moreover interzone (thermal resistance) models are discussed, describing the transition between bulk driven flow and boundary conditions. Such a model would allow a better evaluation of the energy consequences of inhabitant behaviour without the need to use complete building thermal models. Finally, CFD models as those developed at Concordia University, seem well adapted to fulfil the task of validating simplified models.

The single sided ventilation studies were designed to determine the effect of wind on the ventilation and/or heat loss rates through openings in one external wall only. Collaboration between four European laboratories led to several contributions.

New Publications in Air Infiltration and Ventilation

European Concerted Action, Indoor Air Quality and its Impact on Man, Environment and Quality of Life, Report No 11, EUR 14449 EN

Guidelines for Ventilation Requirements in Buildings

Office for Publications of the European Communities, Luxembourg, 1992

These Guidelines recommend the ventilation required to obtain a desired indoor air quality in a space. The first step is to decide the air quality aimed for in the ventilated space. A certain air quality is prescribed to avoid adverse health effects while a decision is required on the level of perceived air quality aimed for in the ventilated space. Three different comfort levels are suggested. The next step is to determine the pollution load on the air caused by pollution sources in the space. The total pollution load is found by adding the loads caused by the building and by the occupants. The available outdoor air quality and the ventilation effectiveness of the ventilated space are also considered.

The ventilation rate required to provide the desired indoor air quality is then calculated based on the total pollution load, the available outdoor air quality and the ventilation effectiveness. The ventilation rates required for health and comfort are calculated separately and the highest value is used for design.

Air Flow Studies in Multizone Buildings - Models and Applications

by Magnus K Herrlin

Department of Building Services Engineering, Royal Institute of Technology, Stockholm, Sweden, Bulletin No 23

Swedish Council for Building Research, September 1992

Air flow studies in multizone buildings have been somewhat limited because simulation programs for interzonal air flows in buildings have not been readily available. The approach in this research was to develop a computer program for simulating air flows and pollutant transports in multizone buildings and to demonstrate its application to a typical Swedish multistory residential building, with emphasis on a comparison of exhaust and exhaust-supply ventilation systems. Studies were performed under different climatic conditions and assumed normal building operations and typical building leakage levels. For floor plans, dimensions, and building materials, excellent statistics are available. A considerable amount of good quality data was also found for duct components and weather statistics. As for leakage data, however, very little is available for multizone structures. The steady-state air flow model described here simultaneously solves the interzonal flows and the flows in ventilation ducts; the fast and reliable solver used stood up well against other methods. At highly turbulent conditions, steady-state assumptions can introduce significant errors; accordingly, the model is better suited for parametric studies than as a tool for evaluating full-scale measurements. The dynamic pollutant transport model was found to be useful for estimating air movements in the building. Even though the absolute air flow changes were generally small, there were clear differences in the performance of the two ventilation systems. The exhaust-ventilation system allows a pressure hierarchy that is beneficial for controlling interzonal air flows and exfiltration. This hierarchy turns into a disadvantage under some normal building operations, however, and substantially reduces the air exchange rates in upper-level apartments. The exhaust-supply ventilation system guarantees minimum air exchange under all conditions. A drawback of this system is that air flows from apartments on the lower levels to apartments on the upper levels via the staircase, and pollutants can also be transported. Because of varying temperatures in the central air handling unit, variations in exhaust and supply flow rates are fairly large. In both systems, the air exchange sensitivity to increased leakage levels was small to moderate. The development and application of this program promises to enhance the way we approach air flow studies in multizone buildings and thereby encourage future research in this and related fields.

Forthcoming Conferences

Quality Standards for the Indoor Environment: Scientific and Regulatory Aspects
13 December 1992
VENUE: Prague, Czechoslovakia
CONTACT: Professor M V Jokl, c/o Secretariat: Quality Standards for the Indoor Environment: Scientific and Regulatory Aspect, Society for Environmental Technology, CS 116 68 Prague 1, Czechoslovakia
Fax: +42 2 232 8611

Thermal Performance of the Exterior Envelopes of Buildings V
DATE: December 7-10, 1992
VENUE: Clearwater Beach, Florida, USA
CONTACT: Jeffrey E Christian, Building Thermal Envelope Systems and Materials, Oak Ridge National Laboratory, P O Box 2008, Oak Ridge, TN 378316070, USA
Tel: +1 615 574 5207

Building Design, Technology and Occupant Well Being in Cold and Temperate Climates
DATE: 17-19 February 1993
VENUE: Palais des Congres, Brussels, Belgium
CONTACT: Agitour, Avenue Louise, 265, B1050 Brussels, Belgium
Tel: 32 2 649 81 70
Fax: 32 2 649 32 62

EEB International Symposium
Energy Efficient Buildings
Design, performance and operation under the auspices of the CIB Working Group W67: energy conservation in the building environment
DATE: March 9-11, 1993
VENUE: University of Stuttgart, Germany
CONTACT: U Fadel, Nobelstr. 12, 7000 Stuttgart 80, Germany
Tel: +49 711 970 3360
Fax: +49 711 970 3395

Indoor Air '93 The 6th International Conference on Indoor Air Quality and Climate
DATE: July 4-8, 1993
VENUE: Helsinki, Finland
CONTACT: Indoor Air '93, Prof Olli Seppanen, Helsinki University of Technology, SF02150 Espoo, Finland
Tel: 358 0 451 3600
Fax: 358 0 451 3611
THEMES: Human health, comfort and performance; indoor air quality and climate; control technology; policy, regulatory and legal issues

Heat Pump for Energy Efficiency and Environmental Progress
The 4th International Energy Agency Heat Pump Conference
26-29 April 1993
VENUE: Maastricht, The Netherlands
CONTACT: 4th IEA Heat Pump Conference, Conference Secretariat, Van Namen & Westerlaken, Congress Organization Services, PO Box 1558, 6501 BN Nijmegen, The Netherlands
Tel: +31 80 234471
Fax: +31 80 601159

International Building Performance Simulation Association. Third International Conference Building Simulation '93
16-18 August 1993
VENUE: Adelaide, Australia
CONTACT: Building Simulation '93 Secretariat, 264 Halifax Street, Adelaide, Australia 5000, PO Box 44, Rundle Mall, SA 5001
Tel: +618 232 3422
Fax: +618 232 3424
THEMES: Technology Transfer - user needs, integrated design tools
Applications - building performance simulation in practice, intelligent buildings and diagnostic routines
Simulation approaches - computing environments, relational data bases, expert systems, hypermedia
Fundamentals - conceptual models for building performance evaluation
Validation - quality control and assurance

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

CLIMA 2000 Engineering the Built Environment
November 13, 1993
VENUE: Queen Elizabeth II Conference Centre, London, Great Britain
CONTACT: CLIMA 2000, c/o CIBSE, 222 Balham High Road, London SW12 9BS, Great Britain
Fax: +44 81 675 5449
THEMES: Environmental and resource issues; design criteria relating to human safety, health, comfort and performance; component and system design and application; system and equipment performance, prediction and measurement; system commissioning, design and operation standards; education, training and qualification routes.

Roomvent '94
June, 1994
VENUE: Krakow, Poland
CONTACT: Prof Stanislaw Mierzwinski, Institute of Heating, Ventilating and Air Conditioning, Silesian Technical University, U1, Pstrowskiego 5, PL 44100 Gliwice, Poland

3rd fold (insert in Flap A)

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)

1st fold

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

AIVC Conference Proceedings Nos 1-10 are now available at £10 each to clear. This is a nominal cost to cover our postal rates.

		P	NP
[ ]	1st*		
[ ]	2nd*		
[ ]	3rd		
[ ]	4th		
[ ]	5th		
[ ]	6th		
[ ]	7th		
[ ]	8th		
[ ]	9th		
[ ]	10th		
[ ]	11th	£35	£35
[ ]	12th	£50	£50
[ ]	13th	£50	£50
[ ]	mf set	£75	£75

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				
[ ]	TN5.4	Free	£10	[ ]	TN23	£15	£25	[ ]	TN31	Free*	N/A*				
[ ]	TN10	Free*	£15*	[ ]	TN24	Free	Free	[ ]	TN32	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 Annex Reports

[ ] 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'.

AIVC CONFERENCE PROCEEDINGS

- 1st 'Instrumentation and measuring techniques',Windsor, UK,1980.
- 2nd 'Building design for minimum air infiltration', Stockholm, Sweden, 1981.
- 3rd 'Energy efficient domestic ventilation systems for achieving acceptable indoor air quality', London, UK, 1982.
- 4th 'Air infiltration reduction in existing buildings', Elm, Switzerland, 1982.
- 5th 'The implementation and effectiveness of air infiltration standards in buildings', Reno, USA, 1984.
- 6th 'Ventilation strategies and measurement techniques', Het Meerdal Centre, Netherlands, 1985.
- 7th 'Occupant interaction with ventilation systems' Stratford-upon-Avon, UK, 1986.
- 8th 'Ventilation technology - research and application', Uberlingen, West Germany, 1987.
- 9th 'Effective Ventilation' Ghent, Belgium, 1988
- 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.
- 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 26 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), Arlon Street 53, 1040 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 3, Norway. Tel: +47 2-96-55-00 Fax: +47-2-965542

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: 01-823-4175 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: 415/486-4022 Telex: 910-366-2037 Fax: 415 486 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