# Air Infiltration Review

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International Energy Agency - AIVC

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# Ventilation and Indoor Air Quality in Schools

*IEA ECBCS Annex 36 report on national guidelines and regulations*

*by Richard Daniels, Building Services Engineer, Architects and Building Branch, Department for Education and Employment, UK*

The IEA Annex 36 Retrofitting educational buildings - an energy concept adviser started in October 1999 and will run for 4 years. As preliminary work a comparison has been made of the different design criteria in the member countries. This is based on a questionnaire which was sent to all participating countries. The questionnaire covers new build and refurbishment work and includes all relevant design criteria, eg, acoustics, lighting levels, energy targets, thermal transmission (u-values), space standards, water supplies, hot water storage temperatures, etc.

A report and spreadsheet summary tables were produced comparing the criteria in the different countries. The tables on ventilation and indoor air quality are presented here. Copies of the questionnaire, the full report and all the summary tables can be obtained from the author (Richard.Daniels@dfee.gov.uk).

Tables 1 and 2 show that standards in England specify a lower minimum ventilation rate than in most other countries (minimum background ventilation of 3litres/second/person, with a capability for rapid ventilation at a rate of 8l/s/p). Furthermore most countries are now recommending a maximum carbon dioxide concentration of between 1000 and 1500ppm. This corresponds to between 7 an 9l/s/p for a classroom.

In more and more countries carbon dioxide concentrations are taken as an indicator of indoor air quality in schools. What evidence is there to support the adoption of this as a minimum standard? The author is aware of one study in schools which proved significant correlations between carbon dioxide levels and pupil performance and pupil health. This was the research done by Rogaland Research in Norway(1&2).

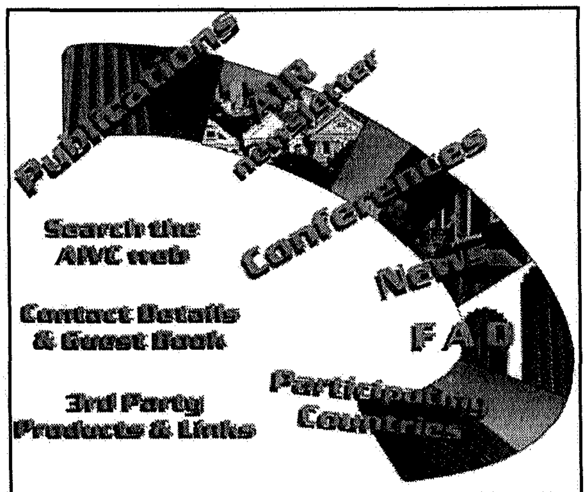
Do we need more research into these associations or has sufficient research been done in schools and other building types to justify the adoption of maximum recommended carbon dioxide concentrations in schools. The author would like to hear the views of readers on this subject and in particular about any other relevant research.

*In this issue*

| Ventilation rates | Austria | France | England | Denmark | Germany | Poland | Finland | USA and Canada (ASHRAE) |
|---|---|---|---|---|---|---|---|---|
| | | | >5 l/s/person [1] during occupancy<br>9l/s/p recommended for UK in HSE (GN EH22) to control odours<br>Natural ventilation<br>**3 l/s/person of background ventilation[2]**<br>**8 l/s/person capability for rapid ventilation[2],**<br>eg. by opening windows | | **5.6 to 16.7l/s.p or 1.1 to 5.6l/s.m²**<br>0.5ach⁻¹ minimum | | **6 to 8 l/s/p or 3 l/s.m²** | follow ASHRAE Standard 62-1999<br>Standard sets minimum levels of ventilation (outside air input) per occupant.<br>NB. There is a current proposal to reduce the minimum ventilation rate in Standard 62-1999 for classrooms from 8l/s/p to 3l/s/p |
| Nursery | | **2.8l/s.m²** | | **3.1 - 5l/s/p or 0.4l/s.m²** | | | | |
| *Primary School* | 4.2l/s/p | **2.8l/s.m²** | | | | | | |
| Secondary School | 5.5l/s/p | **3.3l/s.m²** | | | | | | |
| Classrooms | | | | **5l/s/p or 0.4l/s.m²** | **5.6l/s.p or 4.2l/s.m²** | **5.6l/s.p** | | **8l/s/p or 15 cfm/p** |
| Laboratory | | | | | | | | **10l/s/p or 20cfm** |
| Hall gym use | | | | | | | **12 l/s/p or 2 l/s.m²** | |
| Hall auditorium use | | | | | | | **8 l/s/p or 6 l/s.m²** | **8l/s/p or 15cfm/p** |
| Lecture room | | | | **5l/s/p or 0.4l/s.m²** | **5.6l/s.p or 4.2l/s.m²** | **5.6l/s.p** | **8 l/s/p or 6 l/s.m²** | |
| Lunch room | | | | | | | **6 l/s/p or 5 l/s.m²** | |
| Lobby/hallway/exhibition area | | | | | | | **4 l/s/p or 1 l/s.m²** | |
| Washrooms | | | **6 ach⁻¹** | | | | | **Restrooms 10l/s/p or 20cfm/p continuous** |
| **Air velocity** | <0.1m/s winter<br><0.25m/s summer | 0.05 to 0.15m/s | | 0.05 - 0.15m/s | <=0.15m/s | | **See graphs[3]** | |
| **Relative humidity** | 30 - 55% | | | | 40 - 60% | | 25 - 45% winter<br>30 - 60% summer | 30-70%(ASHRAE) |
| **Mechanical ventilation** | | | UK >5 l/s/person or >(10l/s/p if smoking allowed) (BS 5720:1979 Code of Practice for Mechanical ventilation and air conditioning) | **5l/s/p or 0.4l/s.m²** | | 5.6l/s.p | 6 l/s/p or 3l/s.m2 | |
| **Air tightness** | | <0.2 Vol/hr when heated | | | | | | |
| **Electricity consumption** | | | | **< 2500 J/m³ of fresh air** | | | | |

*Table 1: Ventilation parameters. Values in bold type are regulations, values in normal type are recommendations. (1) Approved Code of Practice and guidance in support of the Workplace (Health Safety and Welfare) Regulations 1992. (2) School premises Regulations 1999 (3) National Building Code of Finland, D2: Air temperature and effective temperature plus draft characteristic used to determine maximum air velocity from a graph (Figure 1 in Building Code). Max velocity increases with space temperature. For classrooms velocity <0.15 m/s.*

# Air Infiltration Review

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*Edited by Janet Blacknell*

**AIR is also available online at www.aivc.org**

| | Austria | Denmark | Norway | Germany | USA and Canada (ASHRAE) | Canada | New Zealand | Japan | Finland |
|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ (ppm) | No limit or guideline but 1000 or 1500 under discussion | 1000 with upper limit of 2000 | <1500ppm[1] | <1500 but preferably <1000 | <1000 ASHRAE Standard | 800ppm[1] (Workday average) 5000ppm [2] (TWAEV) | 1000ppm [1] | **1500** but 1000 for acceptable IAQ | 1500 and 800 if $CO_2$ controlled system |
| CO (ppm) | | | | | 9 ppm ASHRAE ave. over 8 hrs | 5ppm [1] (Workday average) 35ppm [2] (TWAEV) | | | |
| Ozone | | | | | | 0.1ppm [1&2] - peak level 0.08 WHO - criteria document | | | |
| VOCs | | | | | 1 - 5 mg/m$^3$ US EPA guidelines | | 0.5mg/m$^3$ [2] | | |
| Nicotine | | | <1 microgm/m$^3$ (smoking areas) <10 microgms/m$^3$ (Non-smoking areas) | | | | | | |
| Dust mites | | | 1 microgm Derl allergen/gm dust (50 mites/gm dust)[1] | | | | | | |
| Total Fungi | | | | | | | <400cfu/m$^3$ [3] | | |
| Total Bacteria | | | | | | | <100 cfu/m$^3$ [3] | | |
| Nitrogen dioxide | | | | | 0.05ppm Annual national ambient air quality standard (USA) | 3ppm [2] (TWAEV) | | | |
| Radon levels | | | 200-400Bq/m$^3$ simple measures >400Bq/m$^3$ inc. all high cost measures Future buildings<200Bq/m$^3$ | | 4pCi/litre | 20pCi/litre[3] | | | |
| Formaldehyde | | | 100microgms/m$^3$ (30 min sampling) | | 0.4ppm | 1ppm [2] (TWAEV) | 0.1ppm [1] | | |
| Asbestos | | | <0.001 fibers/ml of air [2] | | | <0.002 fibers/m$^3$ [4] | | | |
| Man made fibers | | | <0.01 fibers/ml of air | | | | | | |
| Suspended particles | | | $PM_{2.5}$<20 microgms/m$^3$ (24 hr. sampling) [1] | | Total susp. particles<120 microgms/m$^3$ (US National outdoor air guidelines) | | | | |
| Relative humidity | 30 - 55% | | | 40 - 60% | 30-70%(ASHRAE) | | | | 25-45% winter 30-60% summer |

Norway: [1] suggested guideline; [2] practical guideline

Canada: [1] Ontario Hydro Standard; [2] Ministry of labor Standards; [3] Health & Welfare Canada; [4] (OSHA standard 1986)

New Zealand: [1] mechanical ventilation standard; [2] Australian interim level of concern; [3] unofficial guideline

*Table 2: Indoor Air Quality parameters.*
*Note: Figures in bold are regulations, those in normal type are recommendations.*

Finally, there will be a seminar on Ventilation in Schools at the Institute of Building Services Engineers in London later in the year organised by the Natural ventilation Group of CIBSE which will provide an opportunity to discuss the issue in depth and hopefully reach a consensus in England on design criteria for ventilation and IAQ for both new build and refurbishment work.

(1) Myrhold A.N., Olsen E., Lauridsen O. (1996) Indoor Environment in Schools, pupils health and performance in regards to CO2 concentrations. Proceedings of 7th International Conference on Indoor Air Quality and Climate, Nagoya Japan, 96.

(2) A.N.Myhrvold and E.Olsen of Rogaland Research, Stavanger, Norway, Pupils Health and Performance due to renovation of schools, available from Rogaland Research (www.rf.no).

# AIVC Steering Group Representative Presents PhD Thesis

Peter Wouters has completed his doctoral thesis, "Quality in Relation to Indoor Climate and Energy Efficiency: An Analysis of Trends, Achievements and Remaining Challenges". The thesis focuses on a global analysis in terms of the quality of indoor climate, energy efficiency and the interaction between both of them. Particular attention is given to trends, achievements and the remaining challenges, whereby the attention is focused on the built environment as a whole and on building technology. The publication is expected to be available on CD ROM at the end of the year.

# Multizone Air Flow Modelling (COMIS)

*Technical Synthesis Report*

*IEA ECBCS Annex 23*

**Summary of IEA Annex 23 Multizone Airflow Modelling (COMIS) Within the Energy Conservation in Buildings and Community Systems Programme (Duration 1992 – 1996), by Peter Warren, Published August 2000**

The objective of the annex was to study physical phenomena causing air flow and pollutant transport (e.g. moisture) in multizone buildings and to develop modules to be integrated in a multizone air flow modelling system. The system itself would be user friendly and structured to be incorporable in thermal building simulation models. Furthermore, special emphasis was to be given to providing data necessary to use the system (e.g. wind pressure distribution, default values for leakage of building components, material properties like absorption and desorption). The comparison between results from the model and from in situ tests was to be an important part of this annex.

To reach these objectives the project was structured in three parallel subtasks:

Subtask 1: Implementation of new features in COMIS, including new models and user-friendly interface;

Subtask 2: Collection of both input data and data for comparison with experiment;

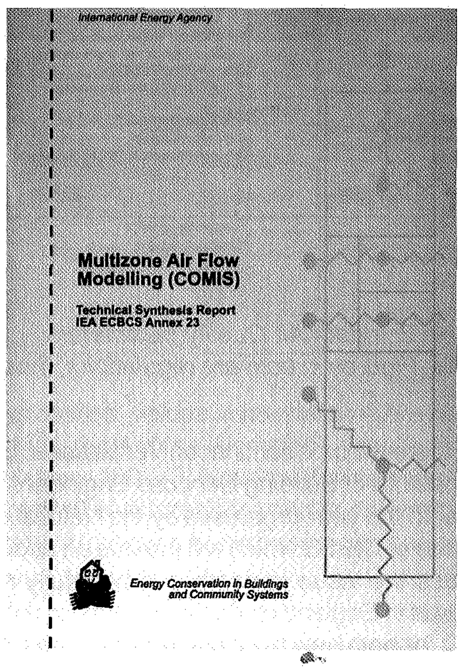
Subtask 3: Evaluation of the code and its User Guide.

It was intended that the results of these subtasks would be addressed to researchers and consultants in order to promote energy efficient design.

The participants were to undertake a task sharing project involving model development, data acquisition and analytical studies.

Expected results were:

- Hardware-independent multizone air flow modelling system;
- User Guide for the modelling system;
- Database of reference cases for evaluation purposes;
- Database of default input values for use of air flow models;




- Document on evaluation exercise;

Report on sensitivity analysis

The participating countries for this task were Belgium, Canada, France, Greece, Italy, Japan, the Netherlands, Switzerland and USA. The work was carried out in collaboration with Annex, the AIVC.

## Scope

The above technical synthesis report contains a summary of the work of Annex 23, the formal duration of which was from 1992 to 1996. It also includes some information on the subsequent development and application of the work. It is intended to provide an introduction to the multizone airflow model COMIS, a review of the extensive work on the validation of COMIS and an indication of its potential for application to the design of building systems. The report is mainly based upon the principal Annex 23 project reports, which are listed in an appendix.

The report is available, price £20.00. Please contact the AIVC for ordering details.

# Passive Retrofitting of Office Buildings : The OFFICE Project

*Elena Dascalaki and Matheos Santamouris, University of Athens*

## Introduction

The aim of the OFFICE research project has been to improve the energy performance and indoor working conditions for office buildings by retrofitting them using 'passive' technologies. The project, partly funded by the CEC, was co-ordinated by the University of Athens with the participation of organisations and research institutes from eight European countries, namely: France, Italy, Germany, Switzerland, United Kingdom, Norway, Sweden and Denmark. The objective was to combine knowledge and expertise acquired through recent research actions on the development of passive solar heating, passive cooling and daylight techniques, with best expertise on retrofitting of office buildings regarding architectural and engineering interventions.

Application of energy conservation techniques, as well as the use of solar and ambient alternative energy sources in offices, requires knowledge of the specific energy characteristics of the buildings. The latter depends strongly on climatic conditions. In order to investigate the possibilities of successful application of retrofitting interventions on buildings located in the four main European climatic regions, a total of ten buildings have been selected to be thoroughly investigated as case studies. The selection of the buildings was based on the requirement to derive a group of buildings presenting the maximum possible variety of features related to the building typology, client requirements, construction details, location, thermal quality of the envelope, type of utilised energy sources and energy consumption.

## Monitoring of the Case Studies

The present state of each of the selected case study buildings was thoroughly investigated using standardised questionnaires for energy as well as indoor air quality auditing. In-situ inspections were carried out by a group of experts in order to collect data regarding the architectural and engineering characteristics, as well as past energy consumption data for the studied buildings. Furthermore, the actual thermal and energy performance of each building was monitored for an 11-month period. During this period the following data were recorded on an hourly basis:

- climatic data from the nearest meteorological station,
- indoor air temperature at representative locations on a typical floor, and
- one supply and one central exhaust air temperature.

The total energy consumption and its breakdown for heating, cooling, lighting and equipment was monitored either using special watt-meters or by reading the meters already installed in the buildings. In the latter case, the recorded values were monthly averages.

Short term monitoring activities involved extensive and detailed hourly recording of indoor and outdoor temperature and energy consumption for periods of one month during summer and winter. Specifically, the following parameters were monitored:

- outdoor conditions (either at the location of the case study or at the nearest meteorological station)
- air temperature and humidity,
- wind speed and direction, and
- direct and diffuse solar radiation;
- indoor conditions and energy consumption
- indoor air temperature at various locations in the building,
- one central supply air temperature,
- one exhaust air temperature,
- fuel consumption for heating, and
- electrical consumption per energy-end use for the whole building.

In additional, specific experiments were carried out in order to assess the quality of the indoor environment regarding lighting and ventilation. The information collected during the monitoring activities and the audit was used in order to spot the problems in each building and specify the main areas of intervention. Moreover, the data from the short term monitoring periods were used in order to develop more accurate computational models representing the actual state of the buildings as closely as possible. These models were the basis for the assessment of the retrofitting interventions proposed for each case study.

## Methodology for Retrofitting Scenarios

Based on the information collected during the energy audits as well as on the analysis of the data from the monitoring campaigns in the investigated buildings, specific retrofitting interventions were proposed for each of them according to their individual problems and requirements as indicated by the above analysis.

Efficient application of energy retrofitting measures in office buildings is mainly related to the application of systems and techniques dealing with the use of:

- passive solar retrofitting options, and
- measures related to the rational use of energy.

The proposed interventions can be classified in the following categories:

- improvement of the building envelope and introduction of passive solar heating techniques and components;
- reduction or, wherever possible, complete avoidance of the use of air conditioners;
- improvement of the lighting conditions, decrease of the energy consumption for artificial lighting and introducing daylight;
- improvement of the efficiency of the selected building services, like HVAC system, production units and domestic hot water.

Actions aiming to improve the envelope of the buildings were classified in the following major types:

- reduction of the heat transmission through the building envelope by insulating external walls, roofs and floors, as well as by replacing frames in bad condition with new ones and single with double glazing for windows and doors;
- reduction of infiltration by sealing the window frames;
- integration of passive solar heating and daylight components;
- improvement of natural ventilation and solar control.

Retrofitting actions aiming to improve thermal comfort conditions during the summer period and decrease the cooling load of the buildings involve interventions aiming to:

- decrease solar and internal heat gains in the building using more efficient and appropriate solar control devices, as well as minimisation of internal gains.
- modulate the solar and internal heat gains in the building using night ventilation as well as techniques taking advantage of the thermal mass of the building.
- dissipate the excess heat of the building into a heat sink at a lower temperature such as the ambient air, ground, sky and water with ceiling fans, natural ventilation strategies, economiser control techniques and evaporative cooling systems.

In order to investigate the effectiveness of various retrofitting interventions on the improvement of the energy performance of the investigated buildings, different types of actions were studied, ranging from simple to global approaches. Three types of retrofitting interventions were considered:

- measures, involving simple actions affecting only one of the above categories;
- scenarios, involving combined actions affecting only one of the above categories;
- packages, involving integrated solutions involving the most efficient combination of actions on all of the above categories.

The retrofitting studies for each building involved an assessment of the proposed measures, scenarios and packages from both energy conservation and economy related aspects. The impact of each action on the energy performance of the buildings was assessed through energy simulations using computer models 'calibrated', so as to describe the actual state of each building as closely as possible. The 'fine tuning' of the models was based on the data collected during the short term monitoring periods. The economic feasibility of each of the proposed actions was expressed in terms of the pay back as well as the amortisation period.

## Rating Methodology

Two new labelling schemes have been developed in the framework of the OFFICE project: a multi-criteria ranking method and a rating method based on principal component analysis. The aim of these methods is to rate and sort buildings or retrofit scenarios according to:

- energy use for heating, cooling and appliances,
- impact on external environment,
- indoor environmental quality, and
- cost.

The ranking method uses the ELECTRE software and permits two or more buildings to be ranked according to several criteria and a weight set representing the preferences of the user of the method. The method is based on about ten criteria representing an acceptable compromise between feasibility and detailed description. The criteria include:

- annual consumption per energy end use,
- pollutant emissions,
- thermal and visual comfort, and
- building cost.

The method was applied to the ten case study buildings and a sensitivity analysis was performed to assess the impact of changing weights of the decision levels.

The rating method is based on a relative classification technique using principal component analysis to rank many buildings from a given building stock according to several criteria related to energy and environment (internal and external). The methodology uses as classification parameters both quantitative (energy) and qualitative (comfort, daylight, indoor quality) parameters and defines a 'reference' low-energy building according to the following data:

- energy consumption for heating, cooling, and lighting (kWh/m2), and
- discomfort hours during the heating and cooling seasons.

## Atlas

The Atlas is a compilation of the results from an assessment of the energy conservation potential of selected retrofitting interventions on European office buildings. Based on a typology study [1] carried out within OFFICE, the European office building stock was considered to include five main building types according to four criteria, namely: degree of exposure, thermal mass, skin dependence and internal structure. Accordingly, the following building types were studied thoroughly:

- free standing / heavy / core dependent / open plan;
- enclosed / heavy / skin dependent / cellular;
- free standing / heavy / skin dependent / cellular;
- free standing / light / skin dependent / open plan;
- enclosed / light / skin dependent / cellular.

The impact of climatic variations on the effectiveness of the above retrofitting interventions was assessed through energy simulations using climatic data from ten locations in the four main European climatic regions, namely:

- Southern Mediterranean,
- Continental,
- Mid Coastal, and
- North Coastal.

Analysis of the results revealed the main trends in the behaviour of buildings belonging to each type. Results are given in the form of software developed in the highly illustrative environment of MATLAB and a report [2].

## Handbook

The main research results from the OFFICE project are given in the form of a two volume Handbook, which will be published by James & James. This aims to provide specific guidance to designers who wish to reduce energy use in existing offices or refurbish an office block using the latest energy saving and environmentally friendly techniques. The first volume is a 100-page Design Guide covering office buildings in Europe (typologies, typical energy consumption), retrofitting strategies and technologies, climatic variations and the relevance of technologies, design standards, design tools and the rating methodology. The second volume is a 100-page collection of material from the case studies presenting ten representative office buildings in nine European countries and the impact of a range of retrofitting interventions on their energy performance. The material is given in the form of ten illustrated brochures edited by the University of Florence based on the individual contributions of the OFFICE working groups.

## Acknowledgements

The authors would like to acknowledge the European Commission for the financial support of the OFFICE project.

## References

1. Tombazis A. and N. Vratsanos (ed.), 'Office building typologies in Europe', Report no OF-1, OFFICE programme, JOR3-CT96-0034.

2. Dascalaki E. (ed.), 'ATLAS on the potential of retrofitting scenarios for offices', Final report, OFFICE programme, JOR3-CT96-0034.

## Further Information

For further information about this project, Matheos Santamouris can be contacted at:

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# ASHRAE's Residential Ventilation Standard Available for Public Review

*Max Sherman, Chairman, Standard 62.2 Committee*

The American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), is the preeminent society in the United States relating to ventilation. Its standards and handbooks are used well beyond North America and form the basis of practice in many countries. ASHRAE has long been in the business of ventilation, but most of the focus of that effort has been in the area of commercial and institutional buildings. Residential ventilation traditionally was not a major concern because it was felt that in the US operable windows and envelope leakage provide enough air. As indoor air quality (IAQ) concerns increase, however, there is now a desire to define levels of acceptability and performance. Many institutions both public and private have interests in IAQ, but ASHRAE, as the technical society that has had ventilation as part of its mission for over 100 years, was the logical place to develop a consensus standard.

Four years ago Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, was split off as a separate task to focus on developing the minimum requirements necessary to achieve acceptable indoor air quality for low-rise dwellings. Acceptable IAQ means that the indoor air will not likely pose a significant health hazard and will not be irritating or have unacceptable odors. Because of the interdisciplinary nature of the topic and the likelihood that this standard would be adopted as part of regulations, the development of 62.2 has had a rather high profile.

Like all ASHRAE standards, 62.2 has used a consensus approach. Like all consensus-building standards activities, there was a lot of give and take. After extensive and sometimes contentious debates consensus has been achieved. In June the ASHRAE Board of Directors approved the recommendations from the project and standards committees and released the standard for its first public review.

The standard has requirements relating directly to ventilation rates and systems, but because the ventilation is intended to produce acceptable indoor air quality, there are also requirements related to controlling certain pollutant sources that could be reasonably expected to be present. Key requirements of the standard include the following:

Whole-House Mechanical Ventilation: The most fundamental requirement in the standard is that there be a continuously operating whole-house mechanical ventilation system. Very few houses in the US have such systems in them today, but they are quite common in other parts of the world. The rate required depends on the size of the house, but is normally in the 20 to 50 l/s range. While a completely stand-alone system can meet this requirement, the standard allows various alternatives to combine the whole hose ventilation requirement with other parts of the HVAC system such as using bathroom fans or air handlers. Passive ventilation strategies are not addressed in the standard.

Kitchen and Bathroom Exhaust Fans: The committee strongly supported mechanical exhaust fans of at least 25 l/s in all wet rooms, but the requirements of the standard contain some exceptions. Kitchens can use recirculating fans when there is a window; toilets can be ventilated by their attachment to a bathroom; laundries can be ventilated by their dryer vent; and bathrooms can be ventilated at lower rates if the fan operates continuously.

Ventilation Equipment: Because poor quality or poorly selected equipment cannot do the intended job, the committee set some minimum equipment specifications for air moving equipment. For example there are sound limits to reduce the likelihood that occupants will defeat systems because of noise. The equipment must have a properly labeled control. There are airflow performance requirements to assure that the correct amount of air will be delivered. These requirements can easily be met by equipment currently on the market, although the standard does have some allowance for phasing in the better quality equipment.

Windows: Although windows do not meet either the whole-house or local exhaust requirements of the standard, the standard does require that most rooms have operable windows or some other mechanism to allow the occupants to increase the ventilation rate as the need arises such as for cleaning, a party, etc.

Air Handler: Central air handlers can themselves be a source of poor indoor air quality. The standard requires that they have some reasonable particle filtration to reduce particle buildup. Because of the proven dangers of having air handlers in garages, the standard encourages such air handlers and associated ductwork to be sealed.

Combustion Equipment: The standard does not address unvented combustion equipment except through kitchen ventilation; it does, however, require that under some circumstances a backdraft test must done on naturally-aspirated combustion equipment in the conditioned space, because of the depressurization that can be caused by exhaust equipment. This requirement, however, is only necessary when the two largest exhaust devices exceed a combined limit.

Carbon Monoxide Alarm: Although some of the above requirements address the problem of carbon monoxide, they are not stringent enough to provide reasonable assurance the CO will not be a problem. Because of the existence of consensus product standards for CO alarms, the committee felt it would be better to require alarms, than to increase the stringency of the other requirements.

The requirements of the standard take up only a few pages, the rest of the standard contains guidance information that should prove quite helpful in applying the standard, including how to select the type of ventilation, how to operate and maintain the system, and how to consider other kinds of sources and air cleaning.

The standard is available for public review until October 10. Copies of the standard and the forms for commenting can be downloaded from the Standards area of ASHRAE website at http://www.ashrae.org I encourage all interested parties to review the standard and provide the committee with thoughtful, constructive input, which will be reviewed prior to the ASHRAE Winter meeting in Atlanta.

# Ventilation Standards – Research Needs and Natural Ventilation

*Report from the Healthy Buildings 2000 Workshop*

*by Andrew Persily, NIST, USA, Martin Liddament, AIVC, UK, and Jorma Railio, AFMAHE, Finland*

## Background

Throughout the world a number of ventilation standards are being developed and debated (e.g. within ASHRAE, CEN and ISO). Many of these efforts are encountering difficulties for a number of reasons, including conflicting interests among the parties involved, gaps in technical information and differences in the perspectives of the nations involved. As these technical efforts have progressed, indoor air quality conferences have featured standards development issues in a number of workshops, paper and poster presentations, and keynote addresses. Many of these discussions have focused on general issues, such as what is an indoor air quality standard, who should develop these standards, what are the roles of health and comfort in these standards, and so on. While these discussions have been interesting and at times even helpful, they have not always moved the dialogue forward. The ventilation standards workshop at Healthy Buildings 2000 is an attempt to focus the discussion on two key issues, rather than continue the discussion of these more general topics.

## Aim and Scope

The workshop will focus on two important issues in the development of ventilation (and indoor air quality) standards. They are the research needed to support this development and the specialised issue of how to deal with natural ventilation approaches in ventilation standards.

The objectives of the workshop are therefore twofold. The first objective will be to develop a list of research issues that need to be addressed to support the future development of ventilation and IAQ standards. The second objective will be to develop recommendations on how to address natural ventilation approaches within ventilation standards.

## State of the Art Review

As various organisations (ASHRAE SSPC 62.1 and SPC 62.2, CEN/TC 156, ISO/TC 205, etc. ) around the world are developing and revising ventilation and indoor air quality standards, the technical bases of their requirements and recommendations are often questioned. While it is appropriate that these standards reflect the latest and strongest science, these scientific bases are not always available on the issues that these standards must address. Examples of the some of the gaps include the health and comfort impacts of many indoor air pollutants, required levels of ventilation to achieve acceptable indoor air quality in a range of space types, and the impact of IAQ control technologies on indoor pollutant levels. While some might suggest that all standards development be put on hold until all these questions are fully resolved, others argue that the standards are needed and must be developed based on the best science available and the practical experience of the thousands of engineers, designers, and building operators who are successfully designing, building and operating buildings. Present standards are a mixture of scientifically validated findings and professional experience (sometimes "guess"), though the user is not always aware of the source of particular standard requirements.

A separate issue that has arisen in the development of some ventilation standards is how to deal with natural ventilation approaches. Natural ventilation is becoming an increasingly popular way to ventilate buildings, based on the potential for energy savings and perhaps for increasing the acceptability of the indoor environment. However, the ventilation rates of such systems are generally more variable, and it can be difficult to determine the ventilation rates and air distribution performance of such systems. Several standards committees have been wrestling with the form of the requirements for such system, in contrast to the requirements for mechanical ventilation approaches (e.g. BS 5925, ASHRAE 62, CIBSE AM10). The requirements for mechanical ventilation are generally in the form of L/s of outdoor air per person or per m2 of floor area, and these values are used to calculate the design value for outdoor air intake by the mechanical system. This intake rate can be measured for a system to verify that the design has been successfully implemented. No analogous approach has been developed for designing and evaluating natural ventilation systems, and this issue is the motivation behind this workshop. In addition, it is worth discussing whether standards covering natural ventilation systems should also address issues of ambient air quality, air distribution and variability in ventilation rates.

## Research Needs

While many research needs were identified and discussed, much of the workshop focused on the goal of designing for IAQ analogously to how we design for cooling loads or structural loads. To support a loads based approach to IAQ design, the following research needs were identified:

- emission data and emission models
- sink data and sink models
- health- and comfort-based exposure limits
- air cleaning technologies and test methods for rating the performance of these technologies
- Another area of discussion was research on occupant satisfaction and expectations. Issues covered include the following:
- different target levels of IAQ performance including higher performance buildings (achieving "pure joy" rather than 80% acceptance)
- field studies to validate requirements based on chamber studies
- monitoring methods to quantify occupant perception, moving from panels and questionnaire to analytic or chemical measures

Attention was also paid to the need for research to demonstrate the value of effective design documentation, commissioning and operation/maintenance. Research on building performance also needs to address the whole lifetime of the building and the ventilation system, including monitoring and maintainability. Principles of the "Design methodology for Industrial Air

Technology" (INVENT 55) can be applied as one basis.

## Natural Ventilation

This portion of the workshop began with a discussion of how ventilation and IAQ standards should address natural ventilation. Several different options for doing so were discussed. The first was simply to specify the required ventilation rates and other performance parameters, but not to make any distinction between natural and mechanical ventilation approaches to achieving these ends. This is the approach currently taken in ASHRAE Standard 62 and by the CEN CR 1752 technical report. Another approach to natural ventilation is to require openings equal to some percentage of the building floor area as is done in some US building codes and in BS 5925. It was also noted that ASHRAE Standard 62 requires demonstration of ventilation rates for natural ventilation approaches, and if they are inadequate then mechanical ventilation must be used. However, no such demonstration in required for mechanical ventilation.

After much discussion, the consensus of the workshop was that natural ventilation should not be treated any differently than mechanical ventilation in standards. In fact, this distinction between natural and mechanical was seen as an oversimplification and perhaps even constraining. A number of so-called "hybrid" approaches that combine natural and mechanical features, such as fan-assisted natural ventilation, were noted as being very promising. A suggestion was made that a statistical approach be employed for both natural and mechanical ventilation, where the requirements would specify the mean and some measure of the distribution of ventilation rates.

The discussion also addressed some of the concerns that have been expressed regarding natural ventilation, such as poor outdoor air quality, indoor humidity control, variation in ventilation rates and air distribution. However, it was noted that the same concerns exist with mechanical ventilation and that approaches have been developed to address these concerns within the context of natural ventilation. Again, these performance parameters are important for all ventilation approaches, and performance criteria need to be developed and met regardless of the system type.

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*Healthy Buildings 2000 – proceedings and workshop reports are available on the web at http://www.hb2000.org and in print/on CD from: info@hb2000.org, published by SIY Indoor Air Information Oy, Tummavuoren Kirjapaino, Vantaa 2000 Finland.*
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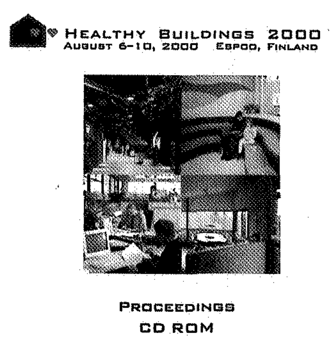

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Occupant Impact on Ventilation, Liddament M W, due 2000 (TN 53) Restricted to participants (£30.00)

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Residential Passive Ventilation Systems: Evaluation and Design, Axley J W, 2000, (TN 54), Restricted to participants (£30.00)

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Annotated Bibliography: Duct Cleaning, Limb M J, 2000 (BIB 10) Restricted to participants (£15.00)

Photovoltaics and Natural Ventilation as Part of Building Facade design - AIRLIT-PV, Liddament M W (TP 1999:5) £20.00 (£20.00)

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## WORLD WIDE WEB

The AIVC's home page is at www.aivc.org.

## GUIDES AND HANDBOOKS

Improving ductwork: a time for tighter air distribution systems, Carrie F R, Andersson J, Wouters P (eds.) (TP 1999:4) £45.00 (£35.00)

Guide to Energy Efficient Ventilation, Liddament M W, 1996 (GV) £60.00 (£40.00)

Air Infiltration Calculation Techniques: an Applications Guide, Liddament M W, 1986, (CT) £22.50 (£15.00)

Air Infiltration Control in Housing: Handbook, Elmroth A, 1983 (HNBK) £22.50 (£15.00)

## TECHNICAL NOTES

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Reporting guidelines for airflows in buildings, 1991 (TN 32) £22.50 (£15.00)

A review of building air flow simulation, 1991 (TN 33) £22.50 (£15.00)

Air flow patterns: measurement techniques., 1991 (TN 34) £22.50 (£15.00)

Advanced ventilation systems, 1992 (TN 35) £22.50 (£15.00)

Airgloss Air Infiltration Glossary, Limb M J, 1992 (TN 36) £22.50 (£15.00)

A Strategy for Future Ventilation Research and Applications, Liddament M W, 1992 (TN 37) £22.50 (£15.00)

A Review of Ventilation Efficiency, Liddament M W, 1993 (TN 39) £30.00 (£20.00)

An Overview of Combined Modelling of Heat Transport and Air Movement, Kendrick J F, 1993 (TN 40) £30.00 (£20.00)

Infiltration Data from the Alberta Home Heating Research Facility, Wilson D and Walker I, 1993 (TN 41) £30.00 (£20.00)

Current Ventilation and Air Conditioning Systems and Strategies, Limb M J, 1994 (TN 42) £30.00 (£20.00)

Ventilation and Building Airtightness: an International Comparison of Standards, Codes of Practice and Regulalions, Limb M J, 1994 (TN 43) £30.00 (£20.00)

Numerical Data for Air Infiltration and Natural Ventilation Calculations, Orme M S, 1994 (TN 44) £30.00 (£20.00)

Air-to-Air Heat Recovery in Ventilation, Irving S, 1994 (TN 45) £30.00 (£20.00)

1994 Survey of Current Research, Limb M J, 1995 (TN 46) £30.00 (£20.00)

Energy Requirements for Conditioning of Ventilation Air, Colliver D, 1995 (TN 47) £30.00 (£20.00)

The Role of Ventilation in Cooling Non-Domestic Buildings, Irving S J, 1997 (TN 48) £30.00 (£20.00)

Energy Impact of Ventilation: Estimates for the Service and Residential Sectors, Orme M S, 1998 (TN 49) Restricted to Participants only (£20.00)

Introduction to Ventilation Technology in Large Non-Domestic Buildings, Dickson D, 1998 (TN 50) Restricted to Participants only (£20.00)

Applicable Models for Air Infiltration and Ventilation Calculations, Orme M S, 1999 (TN 51)

## ANNOTATED BIBLIOGRAPHIES

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

Ventilation and infiltration characteristics of lift shafts and stair wells, 1993 (BIB 1) £22.50 (£15.00)

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Air intake positioning to avoid contamination of ventilation air, 1995 (BIB 4) £22.50 (£15.00)

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Annotated Bibliography: Impact of Urban Air Pollution on the Indoor Environment, Limb M J, 1999 (BIB 9) £22.50 (£15.00)

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

'Ventilation System Performance' Belgirate, Italy, 1990 (CP 11) £35.00 (£35.00)

'Air Movement and Ventilation Control within Buildings', Ottawa, Canada, 1991, 3 volumes (CP 12) £50.00 (£50.00)

'Ventilation for Energy Efficiency and Optimum Indoor Air Quality', France, 1992 (CP 13) £50.00 (£50.00)

'Energy Impact of Air Infiltration and Ventilation', Denmark, 1993 (CP 14) £50.00 (£50.00)

'The Role of Ventilation', Buxton, UK, 1994 (CP 15) £50.00 (£50.00)

'Implementing the Results of Ventilation Research', Palm Springs, USA, 1995 (CP 16) £50.00 (£50.00)

'Optimum Ventilation and Air Flow Control in Buildings', Gothenburg, Sweden, 1996 (CP 17) £50.00 (£50.00)

'Ventilation and Cooling', Athens, Greece, 1997 (CP 18) £65.00 (£65.00)

'Ventilation Technologies in Urban Areas', Oslo, Norway, 1998 (CP 19) £65.0 (£65.00)

20th AIVC Conference Proceedings: 'Ventilation and Indoor Air Quality in Buildings', Edinburgh, Scotland, 1999 CD ROM with printed abstracts and indexes. (CP 20) £65.00 + VAT (£65.00 + VAT)

## LITERATURE LISTS

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20-23 September 2000
Royal College of Surgeons, Dublin, Ireland
*ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329-2305, USA, email dublin2000@cibse.org or dublin2000@ashrae.org*

**Energy for Buildings Fourth International Conference**
21-22 September 2000
Vilnius, Lithuania
*Prof A Skrinska, Organising Committee, "Energy for Buildings", Vilnius Gediminas Technical University, Sauletekio al. 11, 2040 Vilnius, Lithuania, Tel: +370 2 769600, Fax: +370 2 700497, email: energy@konf.vtu.lt*

**Canada's Energy Efficiency Conference and Awards 2000**
October 10-12, 2000
Ottawa Congress Centre, Ottawa, Ontario, Canada
*http://oee.nrcan.gc.ca/conference, Tel: +1 877 633 7440*

**EEBW Energy Saving 2000. Seventh International Conference and Exhibition**
October 17-19, 2000
Congress Centre, Prague, Czech Republic
*SEVEn, The Energy Efficiency Center, Siezska 7, 120 56 Praha 2, Czech Republic, Tel: (02) 2424 7552, 2425 2115, Fax: (02) 2424 7597, email seven@svn.cz, http://www.svn.cz*

**Sustainable Building 2000**
**International Conference**
**Joint conference of CIB W-100, Buildings and the Environment and GBC 2000, Green Building Challenge**
22-25 October 2000
Maastricht, The Netherlands
*Organising Committee SB2000, Ronald Rovers, Novem, PO Box 17, 6130 AA Sittard, The Netherlands, Fax: +31 46 452 82 60, email SB2000@novem.nl, Web site www.novem.nl/sb2000.*

**Cold Climate HVAC 2000**
**The Third International Conference on Cold Climate Heating, Ventilating and Air Conditioning**
1-3 November 2000
The Hokkaido University Conference Hall, Sapporo, Japan
*Scientific Secretariat, Professor Shintaro Yokoyama, Graduate School of Engineering Science, Hokkaido University, Kita-ku, Sapporo, 060-8628, Japan, Tel: +81 11 706 6281, Fax: +81 11 706 7890 or +81 11 706 6281, email: yokoyama@eng.hokudai.ac.jp, http://www.ec-inc.co.jp/cchvac2000/*

**Bioaerosols and Particulates in Indoor Air - Health Effects: the Role of Ventilation - Seminar**
8th November 2000
Chartered Institute of Building Service Engineers (CIBSE), London, UK
*George Leslie, International Society of the Built Environment (ISBE), PO Box 73, Buckden, Cambs., PE18 9SS, Great Britain, Tel: +44 (0)1480 810687, Fax: +44 (0)1480 810768, email: george.leslie@nationwideisp.net*

**Indoor Air Cleanliness: Bioaerosols and Particulates in Indoor Air - Health Effects: the Role of Ventilation**
**A CIBSE Seminar**
8th November 2000
London, UK
*George Leslie, International Society of the Built Environment, PO Box 73, Buckden, Cambs. PE18 9SS*

**ASHRAE Symposium: Experimental Validation of Multizone Network Airflow Models**
27 - 31 January 2001
Atlanta, GA, USA
*Amy Musser, 100 Bureau Drive Stop 8633, Bldg. 226 Rm. A313, Gaithersburg, MD 20899-8633, USA, Fax: +1 301 975 5144, email: amy.musser@nist.gov*

**Indoor Air Health: Second NSF International Conference. Trends and Advances in Risk Assessment and Management**
January 29-31, 2001
Miami Beach, Florida, USA
*Cherrie Bacon, NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105, USA, Tel: +1 734 827 6865, Fax: +1 734 827 6840/6831*

**Brasindoor 2001**
*International Meeting on the Indoor Environment, Ventilation, Health and Comfort*
*25-28 March 2001, Rio de Janerio, Brazil*
*R. Tabapua, 821, cj. 77, Sao Paulo, SP-CEP (ZIP) 04533-013 Brazil, Tel/Fax: 55 11 3849-9334,* ***www.brasindoor.com.br***
*Deadline for abstracts 16th October 2000. In cooperation with Brasindoor, AIVC and ISIAQ. The topics are pollutants, symptoms, architecture and decoration, air conditioning.*

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