Air Infiltration Review

a quarterly newsletter from the IEA Air Infiltration and Ventilation Centre

International Energy Agency - AIVC

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Air Movement and Ventilation Control within Buildings -12th AIVC Conference

24th - 27th September 1991, Hotel Château Laurier, Ottawa, Canada

John Kendrick, Senior Scientist, AIVC

The AIVC's 12th annual conference was devoted to Air Flow and Ventilation Control with special emphasis on the presentations of the results of IEA Annex 18 on Demand Controlled Ventilation and Annex 20 on Air Flow Patterns within Buildings.

Visit to Institute of Research in Construction

Opportunity was taken to precede the conference with a technical visit to the Institute of Research in Construction at the Canadian National Research Council in Ottawa. Of particular interest during the visit was a demonstration of the NRC's large mobile fan, capable of developing a pressure of up to 100 Pa in multi-storey buildings. In addition, ventilation techniques were discussed in the context of test houses, a demonstration was given of flow visualisation using helium filled bubbles, and a slide show gave an overview of the current research programs being undertaken within the Institute.

Dr. Don Strange, the Director General of the Efficiency and Alternative Energy branch of Energy, Mines and Resources formally opened the conference and welcomed over 130 delegates from 13 countries. He emphasised the important role played by the AIVC to aid research into the problems associated with ventilation (a high priority in Canada), and noted that Canada is the third highest user of the AIVC's facilities.

Air Flow Patterns within Buildings

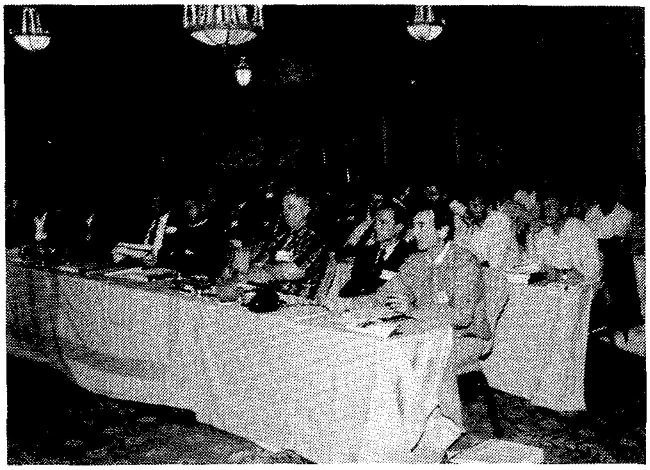
There then followed the first plenary session, chaired by Mark Riley of Energy, Mines and Resources. This opening session was devoted to a presentation of the work and results of Annex 20, Air Flow Patterns

In this issue

Within Buildings and was introduced by the Swiss operating agent, Alfred Moser. Alfred outlined the general objectives of the Annex as the evaluation of single- and multi-zone air and contaminant flow simulation techniques and the establishment of their validity as design tools. The remainder of the session was devoted to presentations of results from the two subtasks of this Annex, SubTask (1) - Single room air and contaminant flow, and SubTask (2) - Multi-zone air and contaminant flow and measurement techniques.

SubTask (1) was based on the approach of solving identical air flow problems in the different participating countries based on the use of near identical test chambers and test configurations. Tasks were shared between measurements of air flow in the chambers and the simulation of the test configurations using computational air flow codes. Speakers providing details of SubTask (1) were Geoff Whittle of Ove Arup, UK who outlined a comparison of measured and computed test case results from this subtask. He concluded that the task of comparing and evaluating codes for room air movement prediction is an ambitious one. However, if the codes are used with care and with good engineering judgment they can make a valuable contribution to the prediction of room air movement. To complete the SubTask (1) presentations, Peter Nielsen from Aalborg University, Denmark, discussed models for the prediction of room air distribution, noting that computational fluid dynamics methods are specially important in cases where air distribution has to be predicted in large enclosures with complex geometries.

SubTask (2) was devoted to the development of new design algorithms for specific problems, including flow through large openings, simulating inhabitant behaviour, analysing air-flow-driven contaminants, and estimating multi-room ventilation efficiency. Items from this subtask were presented by Koos Van der Maas of LESO, Switzerland, who discussed the insights on ventilation caused by wind pressure fluctuations, two-way flow and ventilation energy loss. Roger Pelletret of CSTB, France, presented his paper on the modelling of large openings and how it has become possible to partially validate the "Concordia" code from the experimental results. Jiwu Rao of Concordia University, Canada spoke about wind induces fluctuating air flow in buildings and Hans Phaff of TNO, The Netherlands presented results from the measurements of contaminant driven flows within buildings.



Demand Controlled Ventilating Systems

Session 2, chaired by Professor Fritz Steimle of Fachinstitut Gebäude-Klima, Germany, focused on the results of Annex 18, Demand Controlled Ventilation. Annex 18 was divided into three subtasks; a state-of-the art review, sensor tests and case studies, and a source book covering theory and recommendations. The Swedish chairman of Annex 18, Lars-Goran Mansson of LGM Consult AB, along with Sven Svennberg of RAMAS Teknik AB, Sweden, gave a source book presentation of Annex 18, finishing with recommendations of suitable ventilation systems for various applications. Papers related to Annex 18 continued with presentations by Marco Zamboni of Basler and Hofman, Switzerland, who demonstrated that carbon dioxide is well suited for demand control of ventilation systems in auditoria. Bob Davidge of Public Works Canada continued the theme of DCV with a presentation on the problems of Demand Controlled Ventilation in Offices, and Hans

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.

Stymne from The National Swedish Institute for Building Research used tracer gas methods to conclude that pollutants emitted from a person are transported directly to the upper mixed zone in a room ventilated by a displacement system.

Peter Wouters of the Belgian Building Research Institute discussed the performance evaluation of humidity controlled natural ventilation in apartments, while Willem De Gids of TNO, in The Netherlands extended the theme with a presentation of a paper by Bas Knoll of TNO on the subject of controlled natural ventilation. Andrew Persily of the Building and Fire Research Lab, USA finished the session with a presentation of design guidelines for thermal envelope integrity in buildings. Thus he provided a link between systems and the need to combine strategy with consideration of the building envelope itself.

Display Sessions

The first of the display sessions began with two parallel discussion groups devoted to the results of Annex 18 and 20 respectively. Tony Lemaire of TNO chaired the presentation of Annex 20 and Peter Wouters of the Belgian Building Research Institute chaired Annex 18. During these group discussions each display author gave a short presentation. This was followed by an opportunity for conference participants to visit each poster for a more detailed discussion with the author. Alfred Moser, the operating agent of Annex 20 spoke about the simulation of a multi-nozzle diffuser. Other Annex 20 presentations included, "Multi-room Ventilation Efficiency" by Dominique Bienfait of CSTB, France. Presentations from Annex 18 included "Ventilation and Humidity in Bathrooms" by Jan Fransson of The Swedish National Testing and Research Institute, and "Demand Control Ventilation in a School" from Leif Norell of Flakt Indoor Climate AB, Sweden.

John Talbot of The Department of Energy in the USA chaired the third plenary session entitled "Energy Implications and Field Measurements". The first presentation of this session was given by Johnny Kronvall of Lund University, Sweden who presented a paper on buildings, health and energy and noted that as more demands are imposed on municipal and regional planning with accompanying supply and use of energy, there needs to be a long term national strategy, with clear goals for the environment and energy policy. Marilyn Brown of Bonneville Power Administration, USA, spoke of the energy costs and implementation program for ASHRAE standard 62-1989. Don Alexander of The Welsh School of Architecture, UK, presented the results of, and a comparison between, field experiments and the simulation of infiltration rates and air movement in a naturally ventilated industrial building. Larry Palmiter of Ecotope Inc, USA described the measurements of the interaction of mechanical systems and natural infiltration.

The session continued with Max Sherman of Lawrence Berkeley Laboratory, USA describing single-zone stack-dominated modelling, noting that early field measurements indicated a need for improvements to stack models to handle different construction types and leakage distributions. Anil Parekh of Scanada Consultants Ltd, Canada followed with the comparison of air tightness, indoor air quality and power consumption before and after air-sealing of a high rise apartment building, concluding that air leakage control offers a potential to reduce the peak electricity demand. Professor Fritz Steimle of FGK, Germany completed the session with details of the determination of flow direction by a globe-sensor containing anemometers.

Awards for Best Paper and Poster

The final display session was divided into three topic areas. The first, on the subject of measurement techniques, was chaired by Steve Irving of Oscar Faber Consulting Engineers, UK, and included presentations on tracer gas techniques used in ventilation measurements. Jorn Brunsell of The Norwegian Building Research Institute chaired the poster session devoted to simulation models,which displayed a wide collection of presentations, including turbulent modelling of airflow patterns and ventilation effectiveness by Thomas Kuehn of The University of Minnesota, USA. Presentations on field testing and results analysis were overseen by David Harrje of DTH Consultant, USA.

As part of the conference social programme, a banquet was held at which Dr. Strange was called upon to present the prizes for the best written paper and for the best display presentation. The award for best written paper went to Dr. Roger Pelletret of CSTB, France for his paper entitled "Modelling of Large Openings". Duncan Phillips of the University of Waterloo, Canada received his award for the best poster presentation of "A Novel Infrared Absorption Spectrometer for use in Ventilation Studies." (Articles featured later in this newsletter.)

Roger Pelletret receiving his award for best paper from Dr Don Savage.

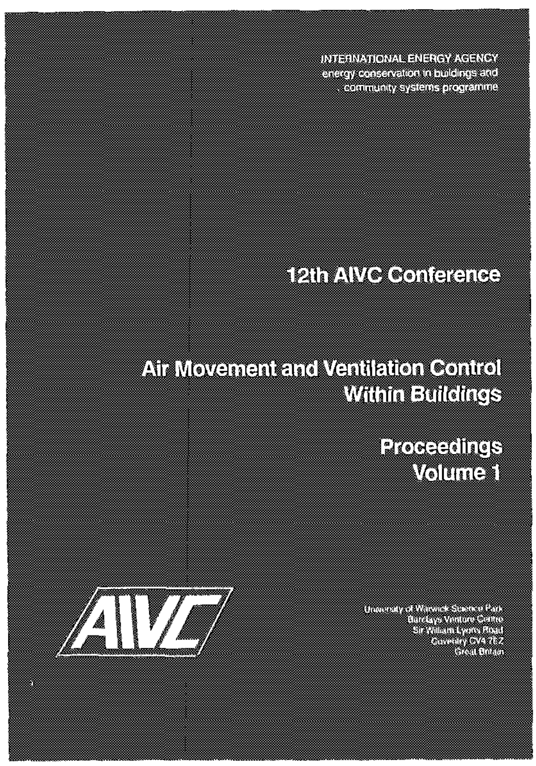
Duncan Phillips receiving his award for best poster presentation

Peter Hartmann of EMPA, Switzerland, chaired the fourth and final plenary session which was devoted to measurement techniques. Earle Perera of the Building Research Establishment, UK, opened this session with a presentation of the assessment of intake contamination from atmospheric dispersion of building exhaust. Earle concluded that, after comparing the wind tunnel results with the ASHRAE prediction for isolated buildings, in general there was acceptable agreement. So in the absence of tunnel data the ASHRAE procedures could be used to provide guidance as to accepted maximum levels of contaminant at intake locations. David Wilson of the University of Alberta, Canada, continued the theme of measurements with a description of the wind shelter effects on air infiltration on a row of houses and showed that wind shelter can change ventilation rates by up to a factor of five for houses in a closely spaced row. Jim Reardon of the National Research Council, Canada, presented a paper on the assessment of airflow patterns in a five-storey apartment building using tracer gas techniques and the large mobile fan seen at the NRC earlier in the week and Jorma Sateri of the Helsinki University of Technology, Finland, presented a paper on the use of PFT measurements in ventilation ducts. He commented that the experiments carried out demonstrated that active (pumped) sampling techniques are preferable to passive techniques in the measurement of airflows in a ventilation system.

Bob Waters of Coventry Polytechnic, UK, gave a presentation on the reliability of infiltration and air movement data obtained from single tracer gas measurements in large spaces. Richard Grot of Lagus Applied Technology, USA presented a paper on the application of tracer gas analysis to industrial hygiene investigations. He provided a summary of three different tracer gas techniques which can be used in industrial hygiene applications, and included the evaluation of computer models for predicting contaminant dispersal. Richard Walker of the Building Research Establishment, UK linked field measurements of tracer gases and the local mean age of air in his paper entitled "Single Sided Natural Ventilation, How Deep an Office?"

Following the presentation of papers, Peter Hartmann presented a summing up of the conference. He remarked on the very broad subject area of the week's proceedings and the high standard of paper and poster presentations. He went on to state that the results of Annex 18 and Annex 20 demonstrated an excellent exchange of information between international research groups. He reminded the audience that this was the twelfth annual conference of the AIVC and that many formats had been used in these conferences to present results. It was essential, therefore, to have feedback to ensure that the correct balance between available time and presentations was maintained. Above all, it was concluded that the limitation placed on participant numbers was necessary to ensure good discussion and interchange of ideas. Peter finished by thanking the delegates for a successful conference and hoped to see everyone at the 13th conference in France in 1992.

A three volume set of the Conference Proceedings along with extensive discussion notes is available from the AIVC, price £50 .00 Sterling.



International Energy Agency

Air Infiltration and Ventilation Centre

13th AIVC Conference

Ventilation for Energy Efficiency and Optimum Indoor Air Quality

Venue: France

Date: Week of 14th-18th September, 1992

First Announcement and Call for Papers

Ventilation is needed in order to meet the metabolic needs of occupants and to dilute and disperse internally generated pollution.

As contaminant sources and concentrations in buildings increase, ventilation is called upon to play a growing role in controlling the indoor environment. This imposes an additional energy load as well as increased capital and operational costs. In turn, extra energy demand feeds back to global concerns over the environmental risk of excess energy use.

The purpose of this conference is to identify the energy impact of ventilation and to assess the practical limit of ventilation as an air quality control mechanism. It is also intended that the conference should look to future developments and future research needs.

Topics cover:

- The energy impact of ventilation (including national and international assessments).
- The role of ventilation in optimising indoor air quality
- Ventilation requirements and standards.
- Ventilation control in hot climates.
- Ventilation control in cold climates.
- Influence of internal heat loads on ventilation needs.
- Designing for heat recovery (including cost implications, examples of energy recovery and payback potential).
- Improved air quality through ventilation efficiency.
- Developments in ventilation strategies.
- Ventilation case studies illustrating improved indoor environment combined with energy efficiency.
- Guidelines for the future - future research needs.

Abstracts of proposed papers on these topics are welcome and should be forwarded to Rhona Vickers at the AIVC by January 31st 1992. Abstracts will be reviewed by March 1992 and accepted papers will be required by 31st July 1992. The conference will take the form of both author presentations and displays, with the final distribution being determined at review. Authors are welcome, however, to state their preference. Proposals from non AIVC countries are welcome.

Forward abstracts to:

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12th AIVC Conference Award Winning Written Paper

Modelling of Large Openings

Roger Pelletret [1], Francis Allard [2] Fariborz Haghighat [3]
Georges Liebecq [4], Jacobus Van der Maas [5],

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Synopsis

The subtask of Annex 20 (Optimization of Air Flow Patterns Within Buildings) involved a research project called "Air Flows Through Large Openings in Buildings". The scope of this project was to test the range of validity of available algorithms and, where possible, to develop new ones. This paper focuses on the new interzonal airflow studies which have been carried out in this frame. The research was based on three test rooms (respectively at the University of Liège, at INSA Lyon and at CSTB Sophia Antipolis), 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 our experimental results. Moreover, these experimental results have been used to validate a C.F.D. (Computational Fluid Dynamics) model developed at Concordia University.

The main results consist of validated models to compute the mass flows in large openings, assuming either isothermal air volumes or linear temperature profiles in both rooms; the discharge coefficient that has been found is about 0.43. Local discharge coefficients have also been determined but this topic needs more studies; C.F.D. models, such as those developed at Concordia University, seem well adapted to fulfil this task as long as they are validated.

List of Symbols

$\dot{m}_h$	Mass flow in the upper part of the opening	(kg/s)
$\dot{m}_c$	Mass flow in the lower part of the opening	(kg/s)
$\dot{m}_{measured}$	Measured mass flow	(kg/s)
$\dot{m}_{computed}$	Computed mass flow	(kg/s)
z_b	Height of the bottom of the opening	(m)
z_n	Height of the neutral plane	(m)
z_t	Height of the top of the opening	(m)
Cd	Discharge coefficient	
W	Width of the opening	(m)
ρ_h	Density of hot air	(kg/m³)
ρ_c	Density of cold air	(kg/m³)
ΔP	Pressure difference	(Pa)
g	Acceleration of gravity	(m/s²)
$V(z)_{measured}$	Measured air velocity	(m/s)
$V(z)_{computed}$	Computed air velocity	(m/s)

Introduction

Numerous studies have been performed on the subject of "Air flow Through Large Openings" connecting two zones at different temperatures. Literature surveys (Barakat 1985, Sandberg 1989, Vandaele and Wouters 1989) have shown that the developed models to compute heat and mass transfer through a large opening generally assume that the flow is one-dimensional and that the interconnected rooms are isothermal; the only free parameter is the discharge coefficient. The three dimensional nature of the flow and the presence of a vertical temperature gradient are then reflected and the discharge coefficient appears to vary from experiment to experiment (the discharge coefficient reported in the literature varies between 0.3 and 0.8 and it is not clearly understood where the difference comes from).

The scope of subtask 2.1 of Annex XX was to test the range of validity of available algorithms, and where possible to develop new ones. This subtask was coordinated by Dr van der Maas from LESO-EPFL, Lausanne, Switzerland; it involves three laboratories in Europe each with a different experimental set-up: the "MINIBât" test cell at INSA Lyon, France, a climatic test cell at University of Liège, Belgium, and the DESYS test cell at CSTB Sophia Antipolis, France. It also involves a laboratory from Concordia University, Montréal, Canada, which has developed a C.F.D. code and is aiming to validate it by comparison with experimental results.

This paper focuses on the new interzonal airflow studies which have been carried out in this area. The research was based on the three above-mentioned test rooms 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 and the analysis of the experimental results.

In this paper, we present first the various laboratory set-ups, then the typical experimental rough results (measured velocity profiles in the doorways). The experimental results are analyzed in order to validate models based on Bernoulli's equation; two models have mainly been validated: a model based on the assumption of isothermal air volumes and a model based on the assumption of linear temperature profiles in both rooms. Finally an example of the comparison between Concordia University's C.F.D. model with some of our experimental results is detailed.

Experimental Set-ups

The three set-ups are described below (see Figure 1); their main common characteristic is to be real scale experiments. The test rooms at the University of Liège and at INSA Lyon are climatic test rooms; the CSTB's set-up is in natural environment.

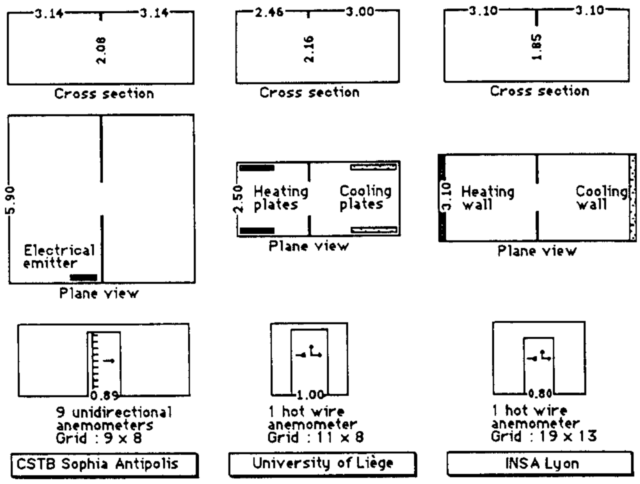

Figure 1: The three laboratory set-ups

The CSTB's test cell is called the DESYS test cell; the DESYS test cell is an 86 m² house built with industrial envelope components whose detailed thermal characteristics have been carefully measured (Pelletret 1987). The test cell area is partitioned into three main zones; the partitions between the zones are very well insulated; one of these zones is divided into two symmetric rooms connected with a large opening.

The experimental studies, carried out at the University of Liège, started with a set of experiments in a calorimetric chamber (Lebrun and Liebecq 1987); then a new set of experiments has been performed to better understand the influence of the width of the door on the heat and mass transfer (Baranowsky 1989). The calorimetric chamber is bounded by a double envelope through which the air temperature is controlled. In the hot zone, heating films were mounted to raise the air temperature and cooling plates were placed in the cold zone to cool it.

The basis of the experimental facility at INSA Lyon is the MINIBât test cell (Allard 1987), built in a controlled environment (each of the two zones is bounded on five sides by air volumes controlled at a constant temperature, the sixth side is submitted to controlled climatic conditions; a solar simulator and electrical heating films located along the surfaces on the internal side of the walls of the two rooms complete the setup and enable the generation of a wide range of boundary conditions.

Velocity Profiles

In the CSTB's test cell, about a hundred experiments with various heights and positions of the opening have been performed. Some experiments have been made with none of the rooms heated or one heated with an electrical emitter but not the other one, or both heated, or one heated and the other one cooled with a cooling air system; but, in general, the experiments were performed with only one room heated as shown in Figure 1; twenty experiments of this kind have been made with an opening height of 2.08 m and fifteen experiments with an opening height of 1.56 m. Figure 2 shows an example of a velocity profile measured with these typical experimental conditions (one room but not the other one) and an opening height of 2.08 m.

In the test cell of the University of Liège, five experiments with an opening height of 2.16 m have been performed. These experiments aimed to approximate the experimental conditions to fit as well as possible with the hypothesis of the mathematical model (which is based on Bernoulli's equation): with symmetrical heating and cooling plates, located as shown in Figure 1, it was possible to minimize the effect of air movements in the rooms due to the thermal devices. The five measured profiles are very similar and the profile shown in Figure 2 is really a typical one.

In the INSA's test cell five experiments with an opening height of 1.85 m have been performed, including two experiments with a cooling wall and a heating wall, two experiments with a single cold active surface and one experiment with a single hot active surface. With two active walls the neutral plane is close to the mid height of the opening; this fits very well with the symmetric boundary conditions. The other profile shown in Figure 2 was measured when only the cooling wall was active; this boundary condition leads to a different airflow pattern within the cooled room and the displacement of the neutral plane (which, in this case, is below the mid height of the opening) is only the result of this fact.

Our goal is to facilitate the comparison between the typical velocity profiles measured in the three test cells. To reach this goal, the velocity profiles are plotted in the same way: the velocity profiles are plotted as a function of the ration z/H where H is the opening height; then, for all the experiments, the ration z/H varies between 0 and 1 (see Figure 2). The velocity profiles are specific for each experimental set-up; the various heating or cooling devices explain why the shapes are different:

- in the CSTB's experiments, the neutral plane is approximately located at the two thirds of the opening height; this is because the electrical emitter creates a specific air movement in the heated room and then a typical vertical temperature profile with a 2 K/m gradient;
- in the Liège's experiments, the neutral plane is slightly above the mid height of the opening; this result fits well with the INSA's experiments when the opposite walls are active;

- *in the INSA's experiments with only the cooling wall active the velocity profile is asymmetric* and the neutral plane is below the mid height of the opening; this result is symmetrical to one of CSTB's experiments and strengthens previous experiments performed in the Liège's test cell with non symmetrical devices: the cooling plates were close to the opening and faced it, then the neutral plane was greatly below the mid height of the opening.

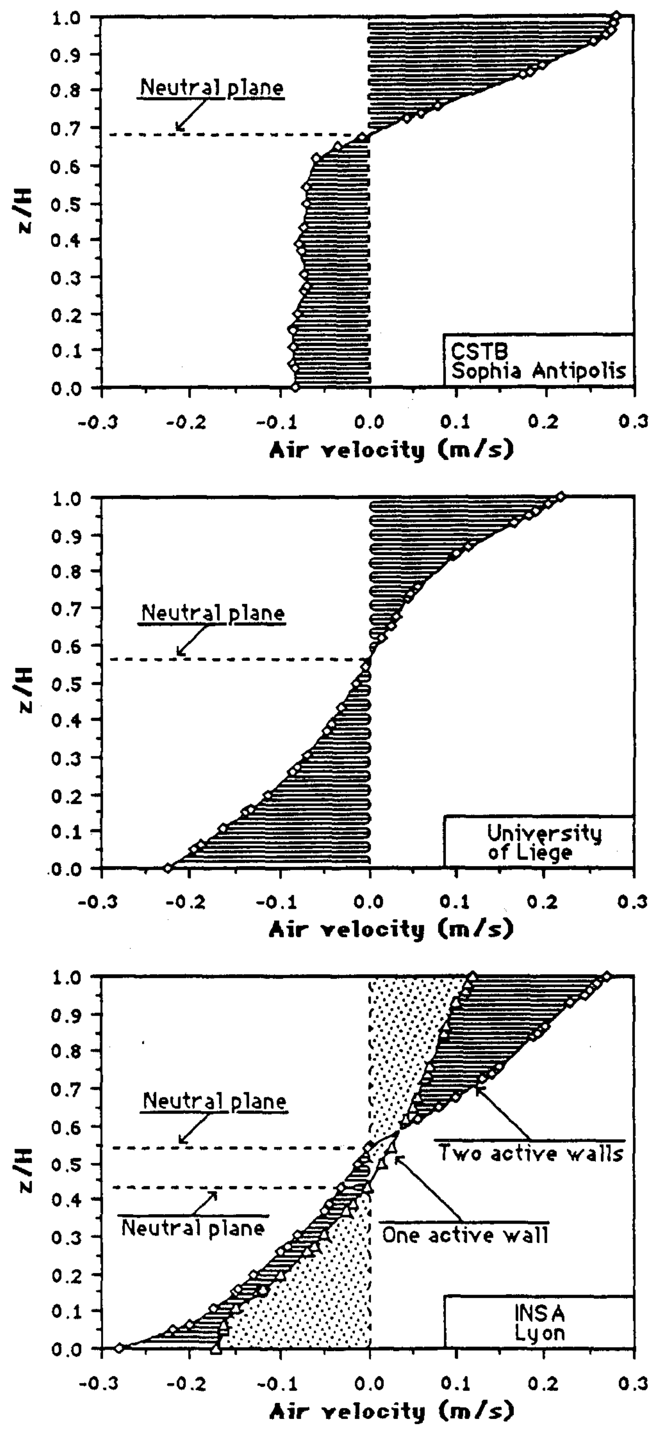

Figure 2: Typical velocity profiles (the plot symbols do not indicate the points where the velocities were measured but only the points where the experimental results have been interpolated in order to plot them in the same way).

Mass Transfer Modelling

Both CSTB and INSA calculated the experimental mass flows by integration of the measured velocity profiles. The University of Liège calculated the experimental mass flows both by integrating the measured velocity profiles and computing it from the heat balance of the test rooms but concluded that to compute them with a heat balance was more accurate in their case.

Assumption of isothermal air volumes

With this assumption of isothermal, the theoretical mass flows are computed as:

$$\dot{m}_h = Cd\,(2/3)\,W\,(2\rho_h)^{0.5}\,\Delta P(z_t)^{3/2}/[\,g\,(\rho_c - \rho_h)] \quad (1)$$

$$\dot{m}_c = Cd\,(2/3)\,W\,(2\rho_b)^{0.5}\,\Delta P(z_b)^{3/2}/[g\,(\rho_c - \rho_h)] \quad (2)$$

In natural convection, $\dot{m}_h = \dot{m}_c$. Equations 1 and 2 are equivalent to equations 3 and 4 when replacing the pressure differences by their expressions as a function of the differences between the heights at the top and at the bottom of the opening and the neutral plane:

$$\dot{m}_h = Cd\,(2/3)\,W\,[2\,\rho_h\,g\,(\rho_c - \rho_h)]^{0.5}\,(z_t - z_n)^{3/2} \quad (3)$$

$$\dot{m}_c = Cd\,(2/3)\,W\,[2\,\rho_b\,g\,(\rho_c - \rho_h)]^{0.5}\,(z_n - z_b)^{3/2} \quad (4)$$

with:

$$z_n = [\rho_h^{1/3}\,z_t + \rho_c^{1/3}\,z_b]/[\rho_h^{1/3} + \rho_c^{1/3}] \quad (5)$$

The Cd coefficient is computed with:
$Cd = \dot{m}_{measured}/\dot{m}_{computed}$

To compare our results, the Cd coefficients are plotted versus the difference between the rooms' average temperatures, but for the INSA's experiments, it is computed as the difference between the two central air temperatures measured in each room (see Figure 3).

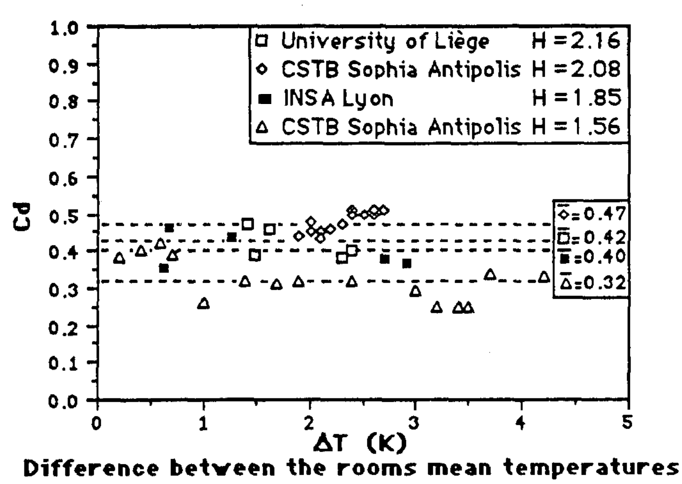

Figure 3. Discharge coefficients with an assumption of isothermal air volumes.

As shown in Figure 3, the results obtained from the three experiments fit quite well:

- the discharge coefficient decreases with the opening height
- the Cd mean value computed from the CSTB's experiments is slightly higher than the Cd mean value computed from the Liège's experiments though the opening heights are similar (2.08 m and 2.16 m); of course this can be explained because of problems of uncertainty in the measurements but presumably this is also because, in the CSTB's set-up, the air movement in the heated zone (due to the electrical emitter) influences the air movement in the opening. And this assertion is strengthened by the INSA's results: for the asymmetric experiments (with only a cooled wall), the Cd coefficient is about 0.45 (close to the mean value of the CSTB's experiments), this value is 20% higher than the Cd mean value computed with symmetric boundary conditions.

Local discharge coefficients

Taking into account the measured temperature profiles in each room and using a model based on Bernoullis's equation, it is possible to compute a theoretical velocity profile in the opening and to compare it to the measured velocity profile; then one can define local discharge coefficients as:

$Cd(z) = V(z)_{measured} / V(z)_{computed}$

Figure 4 shows the typical Cd(z) profiles found with the INSA's experiments and with the CSTB's experiments; each profile depends on the boundary conditions. On these figures, we plotted only three Cd(z) profiles for the CSTB's experiments but the seventeen others are very similar to these three. For the INSA's experiments, one profile is obtained in a symmetric case (two active walls), for the other comparable experiment which has been made at INSA the Cd(z) profile is very close to the one displayed in Figure 4; in this case, it is very interesting to note how much the Cd(z) profile is symmetric. The other plotted Cd(z) profile is for a single cold active wall, the Cd(z) computed for the two other experiments made with only one active wall are quite different from the example plotted in Figure 4; in this case, the discrepancy is greater than with the symmetrical cases or with the CSTB's cases.

Nevertheless, these specific studies have demonstrated that it was possible to define Cd(z) profiles, adapted to a specific configuration, and then the models using these Cd(z) profiles enable an accurate calculation of the mass flows and the velocity profiles (including, of course, the height of the neutral plane).

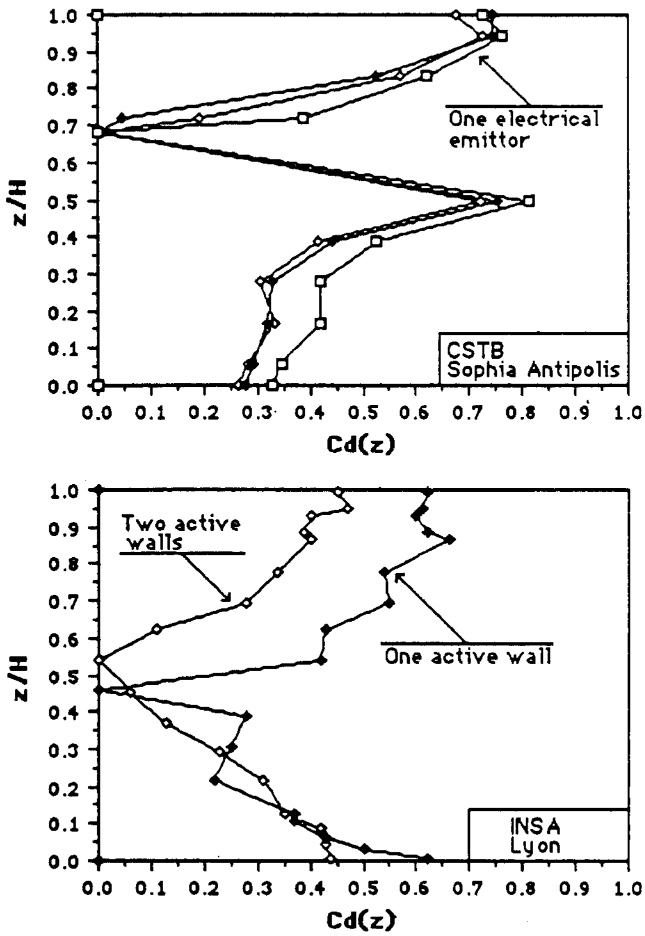

Figure 4: Load discharge coefficients

Comparison with a Computational Fluid Dynamics Code

Brief description of "Concordia" code

This code employs a finite-difference method and the K-ε two-equation model of turbulence to obtain the approximate solution of governing equations for the three-dimensional turbulent flow in rectangular enclosures. At the region near a solid surface, where the viscosity effects become important, the wall function method is adopted to modify the k-ε two-equation model.

More details are given in the final report of Annex XX and in "Haghighat 1989".

Validation

Some comparisons with experimental results from Liège or from INSA have been made. As an example of these comparisons, the measured and the computed velocity profiles are plotted in Figure 5:

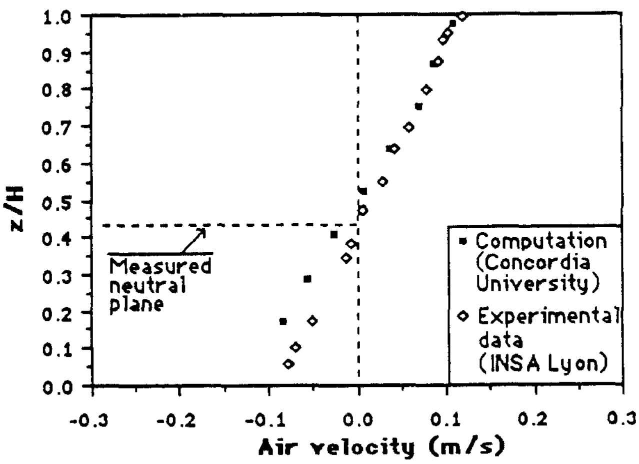

Figure 5: Velocity distribution at the center of door opening in comparison with measurements

A discrepancy is observed in the low region of the door opening. This can be explained because, in this experiment, there was a 0.08 m step on the floor of the door opening and this step is neglected in the computation with the "Concordia" code because it is too small to be considered in a uniform mesh system adopted. In the east part of the door opening, the predicted velocity distribution is in very good agreement with experimental data.

Conclusions

The joint research effort led to the validation of models based on the Bernoulli's equation assuming either isothermal air volumes or linear temperatures profiles. The discharge coefficients in both cases are quite similar; Cd varies from 0.37 in the case of pure natural convection to 0.51 if a (cold or hot) plume exists. An average value of 0.45 seems adequate to correctly model a large variety of configurations such as non-heated rooms, or one room heated not the other one or both heated and for an opening height higher than 2 m. The discharge coefficient decreases with the opening height; a very simple relation as $Cd = 0.21\ H$ fits well with our experimental results in the range $H \in [1.5m\ ;\ 2\ m]$.

The vertical Cd distribution seems to be strongly related to the boundary conditions. Further studies are necessary to define average Cd distribution corresponding to typical boundary conditions or real flow patterns observed in buildings in the case of heating or air conditioning.

More experiments are obviously necessary although experiments are expensive, heavy to carry out, time consuming and, furthermore, in most cases, it is hard to significantly change the design parameters of the experimental set-ups; that is why airflow modelling using computational fluid dynamics could be useful as long as the code is validated; we have begun to make progress in that direction trying to validate the "Concordia" code; this task is not yet achieved but this is a promising way for general parametric studies.

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AIVC 12th Conference Award Winning Display Presentation

A Novel Infrared Absorption Spectrometer for Use in Ventilation Studies

Duncan A Phillips, Gordon M Bragg and Elizabeth J Weckman,
Department of Mechanical Engineering, University of Waterloo, Ontario, Canada

Synopsis

This paper reports on the design, development, calibration and testing of a fast-response, multi-channel tracer gas concentration measuring instrument. The instrument uses an innovative application of Infrared Absorption techniques to measure Sulphur Hexafluoride (SF_6) concentrations. This approach allows the overall cost of a multi-channel continuous-recording unit to be reduced without sacrificing overall performance. A calibration over the range 5.0 to 50.0 ppmV SF_6 is shown. The current measurement resolution is 0.06 ppmV, and the accuracy is +/- 5.0%. Methods of improving these two parameters are presented, and further enhancements suggested.

Introduction

This paper reports on the design, development, calibration and testing of a fast-response, multi-channel tracer gas concentration measuring instrument. Tracer gas concentration measurement instruments are recognised as valuable tools by building ventilation researchers. Currently, these instruments are used to measure ventilation rates - both infiltration and mechanical - from which contaminant trajectories and histories in buildings may be determined.

Many instrumentation systems and experiments, using either Gas Chromatography (GC) [1,2] or a commercially available Infrared (IR) Absorption device [3], have been reported in the literature. A further instrument reported is based on Quadrupole Mass Spectroscopy [4].

Unfortunately, available gas concentration instruments are only suitable for determination of long term changes in contaminant concentration since they are limited by very slow measurement speeds. They do not allow identification of short term, quickly changing local exposure problems, such as "work place exposure zones" (Defined by Corn & Egmen (1979) to be "areas with a consistent pattern of exposure). Furthermore, current instruments do not allow measurement of spatial and time resolved phenomena such as length scales of contaminant concentration. This shortfall is compounded when it is necessary to track contaminant concentrations at more than one location.

Some researchers have attempted to optimize systems using current instruments by combining single analyzers with sophisticated, multi-point, sequential sampling set-ups[1,6,4]. Unfortunately, these are subject to long time delays between measurements while the instrument is flushed. Other techniques have used a separate analyzer for each sample location [7,2].

This leads to significant financial investments in equipment.

The Infrared Absorption Spectrometer described in this paper addresses the problems of measurement speed and cost. In addition, it is intended to have the following characteristics:

a) Ease of transportation;
b) Simultaneous sampling of multiple locations;
c) Real-time continuous monitoring;
d) High signal to noise ratio;
e) Wide range of concentration detection;
f) Minimum support facilities;
g) Long-term, unattended operation;
h) Unobtrusive sampling; and,
i) Low cost.

An instrument with these properties would be capable of studying contaminant spatial correlations both inside rooms, and between rooms; identifying spatial variations in concentration in the region of fume hoods; and performing investigations on the relationship between personal and area sampling in industrial hygiene applications.

Design and Development

Conceptual Considerations

The measurement technique used is Infrared Absorption (IRA) with Sulphur Hexafluoride (SF_6 as the tracer gas. This combination was chosen since SF_6 is widely recognised as a suitable tracer gas, and its detectability by IRA is high.

Gas Chromatography (GC) as a measurement technique was not considered to have a sufficiently fast response time. Authors have reported same-zone-successive-measurement times from 30 seconds [2] to 3 minutes [8] using either a single analyzer for each sample location or sequential sampling respectively. Reported measurement times for IRA indicate sampling times better than 30 seconds.

The initial choice of SF_6 as the tracer gas does not exclude the use of other gases. With a broadbank light source in the instrument, virtually any gas with strongly accessible absorption bands in the infrared could be used to track concentration distribution in space and time.

Functional Description

The instrument consists of five main components:

a) Light delivery optics;
b) Gas sample cells;
c) Sampling system;
d) Custom electronics; and,
e) IBM compatible microcomputer.

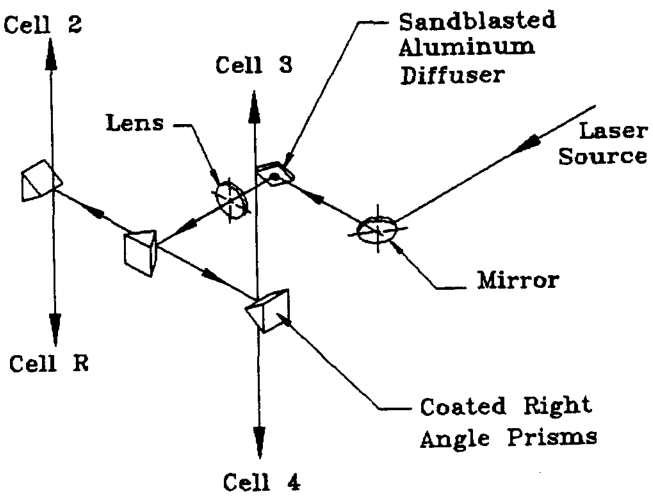

Figure 1: Light delivery optics

The light delivery optics are shown in Figure 1. The three millimetre beam generated by a 10 Watt Carbon Dioxide laser is reflected from a mirror onto an aluminium diffuser. The light scattered from the diffuser is collimated by a 25 cm lens. This light beam is divided into four smaller beams by a series of prisms. These smaller beams are then reflected into the four gas sampling cells. Of the four cells, three are sample cells, and the fourth is a laser power monitoring cell, for normalisation and calibration.

The light beam makes two passes along the length of each gas sample cell before hitting a pyroelectric detector (IR light measuring device). The total path length is approximately two meters in each cell.

Gas samples are continuously delivered to the wide end of each cell, drawn out by a vacuum pump through the narrow end and released to the ambient air (see Figure 2). The sample flow rate is set for each cell using a high precision rotameter and valve. The cell volume is 4.0l

The custom electronics consist of two parts. Digital elements control the laser triggering and operation condition, the tracer gas delivery system, and the timing of sample readings by the computer. Analog electronics use lock-in amplification techniques to resolve small signals from the pyroelectric detectors, and computer controlled gain switching to extend the operating range of the instrument.

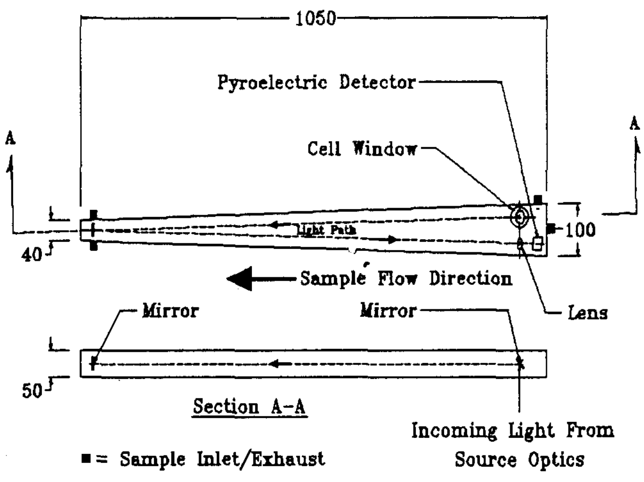

Figure 2.Gas sample cells. Top view

An IBM compatible computer provides the overall control of all functions and logs the data for subsequent processing. Post experiment digital filtering [3] allows high resolution concentration measurements in time *without* waiting for the sample cell to be flushed.

For mobility, the instrument is mounted on a trolley, and a hand cart is used to carry the SF_6 tank and associated gas handling hardware.

Calibration and Testing

Calibration

Calibration is done using a recirculation system with a 32 litre mixing chamber to ensure uniform test sample mixing. A precise quantity of tracer gas is injected into the mixing chamber, and the signal from the pyroelectric detector in the sample cell is monitored until steady state is reached. At this point a reading is taken. Repeated over the calibration range a calibration curve is developed for the sample cell (See Figure 3).

To reduce the effect of the laser instabilities, a relative laser power value is monitored at all times and is used to normalize the signal from the sample cell. To ensure day to day calibration continuity a zeroing value is taken at the beginning of a calibration. The governing equation/calibration curves follow the relationship:

$$c_i(t) = \frac{1}{K_{1i}} \ln \left[\frac{1}{K_{2i}} \frac{S_i(t)}{S_r(t)} \frac{S_r(c_i=0)}{S_i(c_i=0)} \right] \qquad (1)$$

In the above expression is the SF_6 concentration measured in time, is the signal from the pyroelectric detectors, and K_1 and K_2 are calibration constants. The subscripts r and i refer to the reference cell, and any of the sample cells respectively.

Figure 3 illustrates a typical calibration curve obtained for mid range concentrations of SF_6 in a sample cell. Points are shown for concentration increments of approximately 3 ppmV. Each data point on the graph is the average value of at least two blocks of data taken at different times. Each data block is in turn the average of 1500 consecutive measurements of SF_6 concentration. Within each data block (1500 points) the repeatability was +/-1%, giving a limiting sensitivity/resolution of 0.06 ppmV for the lowest measured concentration. The current accuracy of the instrument is +/- 5.0%.

Block to block repeatability was not as good - typically 3.2% (average) - due to problems with the stability of the laser mode as well as uncertainties in the normalization procedure. These problems are currently being investigated, but should be solved using a combination of water cooling of the laser, and digital filtering of the detector signals. These improvements are expected to improve both the resolution and sensitivity of the instrument.

Testing

Figure 4 illustrates the typical concentration decay of a single gas cell from a uniform concentration to zero. In this test, the flow rate of fresh air into the SF_6 "contaminated" cell was set at 16.0 l/min, and the cell volume was 4.0 l. The starting concentration was 21.9 ppmV and the cell was well mixed. Full evacuation of the cell took 28.5 seconds or approximately two times the minimum expected evacuated time (4.0 [l]/ 16.0 [l /min]). As a result, a time resolution of 5 times 15 seconds, or 75 seconds may be expected to be accurately recorded. This sampling time may be reduced by increasing the flow rate.

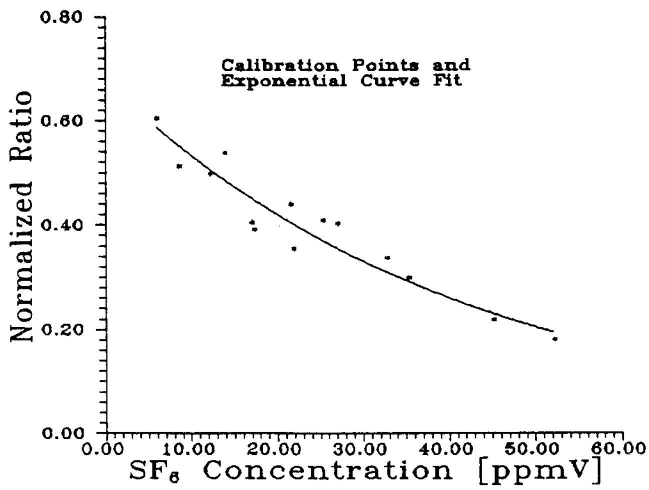

Figure 3: Calibration curve, normalized signal versus concentration

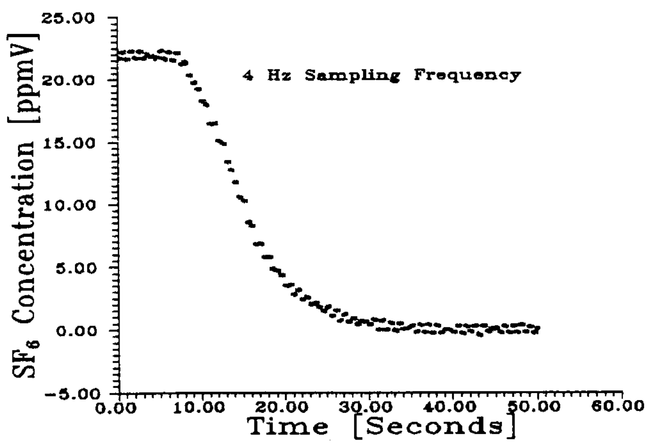

Figure 4: Concentration decay curve from 21.9 to 0.0 ppmV SF_6

Summary and Conclusions

Currently, the accuracy of this instrument is +/-5%. The resolution is 0.06 ppmV, and the maximum time required between samples is 75.0 sec. Water cooling of the laser, and further digital filtering of the output signal should improve the overall system performance.

Further Enhancements

The current measurement system consists of three sample cells/channels, however, one advantage to this system is the ease with which additional sample cells may be added to allow the measurement of concentrations in more zones.

In addition, since the IRA system works on the principle that different gases absorb different wavelengths of light, the instrument can, with the addition of a broadband light source, test for a variety of gases at numerous locations simultaneously. In practice this would mean that a continuous variable light filter, with computer control of its setting would be switched back and forth between the absorption wavelengths of the various gasses of interest. The speed of switching and accuracy would depend on the speed of the measurement electronics and repeatability of the computer controlled filter.

With these enhancements the instrument is capable of performing *near-simultaneous,multi-zone, multi-tracer gas* concentration measurements from the same gas sample, should a broadbank light source be provided. This feature would be a clear advantage for researchers using multi-zone and multi-gas analytic/experiment methods.

Acknowledgements

The financial support of the Natural Sciences and Engineering Research Council (NSERC) of Canada is gratefully acknowledged.

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IEA Energy Conservation in Buildings and Community Systems
Annex 18 Demand Controlled Ventilating Systems

Sensor Market Survey

At the end of the year the Sensor Market Survey report will be published as a part of the work within Annex 18, Demand Controlled Ventilating Systems (DCV Systems). The author of the report is Dr Willigert Raatschen, Dornier Systems GmbH, Germany.

The survey was completed in July 1991 and has been reviewed over the autumn by Annex participants and by the Executive Committee of the IEA Energy Conservation in Buildings and Community Systems Programme.

Only commercially available sensors are detailed in the report. They will govern the ventilation system when activated by airborne pollutants including indicators. A DCV system in Annex 18 is defined as a ventilation system in which the air flow rate is governed by airborne pollutants.

A questionnaire was sent to 69 companies and 21 replies were received, giving information about 52 sensors with the following distribution:

- humidity sensors 26 types
- CO_2 sensors 7 types
- mixed gas sensors 7 types
- combined and miscellaneous 12 types

In the survey sensors from 10 countries are featured.

The survey gives information on

- address, phone, fax of contacts
- measurement principle of sensor element
- measuring range
- influencing factors (temperature, humidity, atmospheric pressure)
- measuring properties (accuracy, sensitivity, rise time, repeatability, and long term stability)
- output signals
- power requirements
- price

The Sensor Market Survey will soon be available and can be ordered from the AIVC.

Efficiency Measurement of Kitchen Hoods

B Geerinckx, P Wouters, L Vandaele
Belgian Building Research Institute

Abstract

Kitchen hoods play an essential role in the ventilation of kitchens. This paper describes activities carried out at BBRI with respect to the determination of kitchen hood efficiencies [1]. The link with European standardization is also described.

Introduction

The main function of a kitchen hood is to extract pollution from cooking in order to keep the pollution level in the occupied space as low as possible. This level is not only determined by the extracted air flow rate but also by the shape and location of the kitchen hood and by surrounding factors: moving persons, open doors, etc.

The determination of kitchen hood performance is currently being discussed by the European Standardization Committee, CEN, in its working group TC 156 WG 2 within the framework of the European Council directive on building products (December 1988). The efficiency of kitchen hoods is related to the essential requirements: 1) "Energy" and 2) "Hygiene and Health".

Given the fact that two measurement methods already exist, (described in the French standard NF E 51-704 [2] and in the Swedish standard SS 433 05 01 [3]), it is logical to take these methods as a starting point.

A detailed study of the effect of various parameters on the performance of kitchen hoods has been performed earlier by CETIAT (F) and is reported in [4].

The Test Facility

The test chamber

Given the fact that there are some differences between the above mentioned standards, the information in the rest of this article is a description of the method applied at the BBRI.

Figure 1 shows the BBRI test chamber. More details can be found in [1]

An essential part of this chamber is the so-called interference device, (height: 1.0 m, width: 0.5 m), which aims to reproduce the disturbance due to occupancy. Such a device is required according to the Swedish standard (not in the French standard).It moves in front of the kitchen hood. It is important to mention that in the Belgian test chamber this panel moves backwards and forwards over a distance of one meter with a speed of 0.5 m/s and a frequency of 0.125 Hz.

Below the kitchen hood, a saucepan, diameter 200 mm, height 95 mm, is installed above a hot plate which is at 110°C. In the saucepan, diluted tracer gas is injected at a flow rate of 3 m³/h.

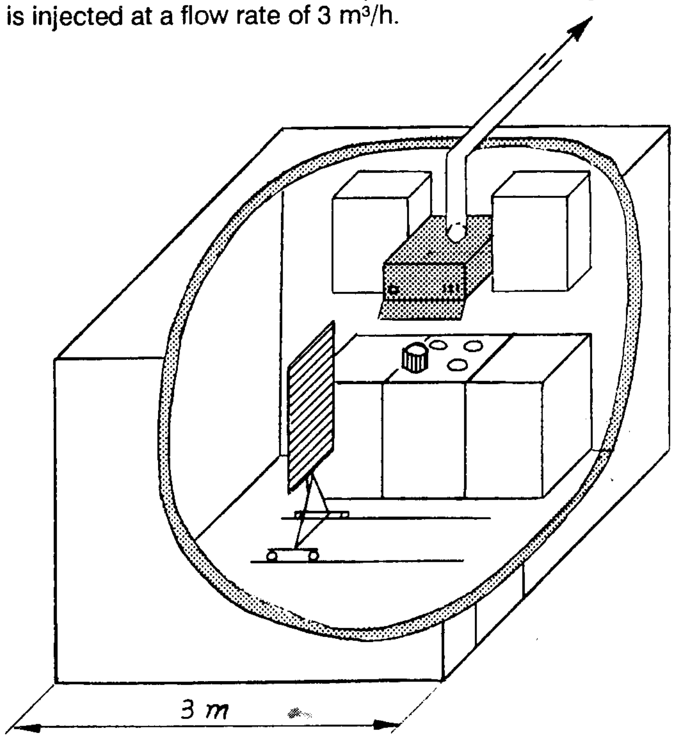

Figure 1: Schematic view of the BBRI test chamber

The test procedure

The test procedure at BBRI is the following (more or less according to the French and Swedish methods):

- the kitchen hood is turned on, the desired air flow rate is obtained,
- the hot plate is stabilised at a temperature of 110°C,
- the interference device is started and the tracer gas is injected,
- after 600 seconds, the injection is stopped,
- 10 seconds later, the kitchen hood is stopped and the air inlet and the extraction are closed,
- in order to obtain a representative reading of the indoor concentration, an internal fan is used for mixing,
- after 600 seconds of mixing, the indoor concentration of tracer gas is measured.

At BBRI the tests are carried out, starting the kitchen hood before the injection of the tracer gas, instead of the proposed procedure in the French and Swedish standard. This improves the repeatability of the measurements, and the modification seems to be reasonable because the main interest is the collecting efficiency at a certain air flow and not during the startup period.

The collection efficiency coefficient can, according to both standards, be calculated by using the following formula:

$$E=1-\frac{C.10^{-6}}{\frac{q}{Q}\left(1-e^{\frac{-Q}{V}t}\right)} \qquad (1)$$

with

E: collection efficiency of the kitchen hood
C : concentration of tracer gas (ppm)
q : tracer gas injection flow (m^3/h)
Q : ventilation flow (m^3/h)
t : injection time (h)
V : volume of the rooms without cupboards (m^3)

The expression in the denominator of this equation is the concentration which should be found in the case of perfect mixing, using the same injection and air flow rate as during the test. Perfect mixing means that the tracer gas is completely mixed with the room air before extraction. An efficiency of 0.00 is found if the concentration inside the test chamber is the same as it would be in the case of perfect mixing.

The tests

During the tests, carried out at BBRI, the concentration of tracer gases in the test room and in the air exhaust is measured every two seconds. Figure 2 illustrates the data obtained during one of the tests.

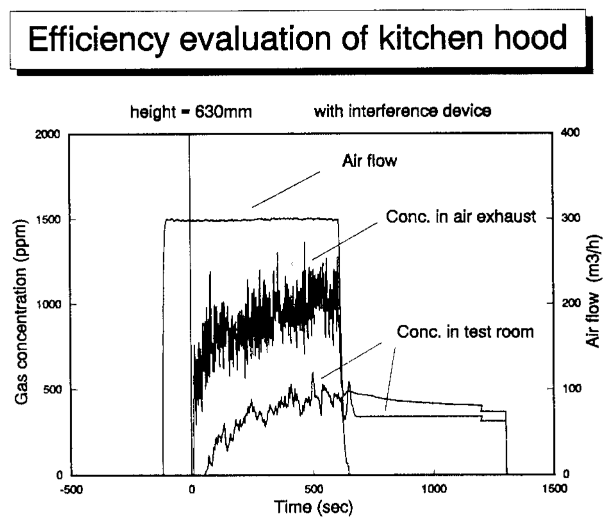

Figure 2: Example of measured concentrations

Overview of some results

For one of the tested kitchen hoods, the effect of the air flow rate and the interference device is shown in Table 1. The kitchen hood is installed 630 mm above the cooker plate. Some tests are carried out more than once. Each value given in the table below corresponds with a complete measurement.

For an air flow of 300 m³/h, the kitchen hood is tested using firstly its original shape and a second time after transformation into an "optimal" ventilation hood. Therefore a plastic foil is used to extend the sides and front of the hood to 10 cm above the cooker.

Efficiency coefficients		
Air flow [m^3/h]	With interference device	Without interference device
450	0.74	0.97
300	0.66, 0.67	0.90
200	0.46, 0.49	0.89, 0.90
100	0.38, 0.39	0.67, 0.71
"optimal" 300	0.94	-

Table 1: Comparative result of different test strategies

The variation of the efficiency as a function of the air flow rate is, without the interference device, rather strange. There is probably a change in air flow.

The results indicate that:

- the shape of the hood has an important effect on the efficiency coefficient,
- the air flow rate has an important effect on the efficiency,
- the interference device as the one used at BBRI dramatically influences the efficiency. It would seem to be the crucial parameter in the tests. It must be stressed that the operation mode during the BBRI experiments probably corresponds with a rather intensive activity level in the kitchen.

What level of efficiency would be found when using a ceiling mounted extraction grill? Table 3 shows the results found for a ceiling grill mounted in the left corner of the room at 50 cm from the rear and side walls.

As could be expected, the results indicate a much lower efficiency than in the case of a kitchen hood.

Efficiency coefficients of a ceiling grille	
Air flow [m^3/h]	With interference device
300	0.33
225	0.25
150	0.23
75	0.13

Table 2: Efficiency coefficients of a ceiling grille.

Interpretation

As indicated earlier, the effect of the interference device in the operation mode used at BBRI is very important. Indeed, a flow rate of 450 m³/h with an interference device gives a similar efficiency to a flow rate of 100 m³/h without an interference device.

Expressing the performance of a kitchen hood by the collection efficiency according to the above formula gives only partial information. Indeed, the effect of the air flow rate on the evacuation of pollutants is largely eliminated by taking as reference the concentration in the case of perfect mixing for the same air flow rate. Therefore, the following definition (the "pollution index") seems to give more information with respect to the pollution in the occupied space: *the pollution index is defined as the relative concentration in the occupied zone for a certain kitchen hood at a certain air flow rate by taking the situation of 100 m³/h extraction with perfect mixing as a reference.*

This corresponds with the following formula:

$$P_i = \frac{C.10^{-6}}{\frac{q}{100}\left(1-e^{-\frac{100}{V}t}\right)} \qquad (2)$$

with:

P_i : pollution index of the kitchen hood

C : concentration of tracer gas (ppm)

q : tracer gas injection flow (m³/h)

t : injection time (h)

V : volume of the room without cupboards (m³)

Table 3 gives the pollution indexes for the same kitchen hood as that reported in Table 1.

Pollution indexes		
Air flow [m³/h]	With interference device	Without interference device
450	0.10	0.01
300	0.18, 0.18	0.06, 0.05
200	0.39, 0.37	0.13, 0.03
100	0.61, 0.61	0.32, 0.29
"optimal" 300	0.03	-

Table 3: Comparative results of different test strategies

The pollution index focusses on the indoor air quality level in the room. The collection efficiency focusses on the indoor air quality for a given flow rate, and it is a more energy related performance index. One can probably come to other performance indices.

Figure 3 illustrates for the tested kitchen hood the efficiency coefficient and the pollution index as a function of the air flow.

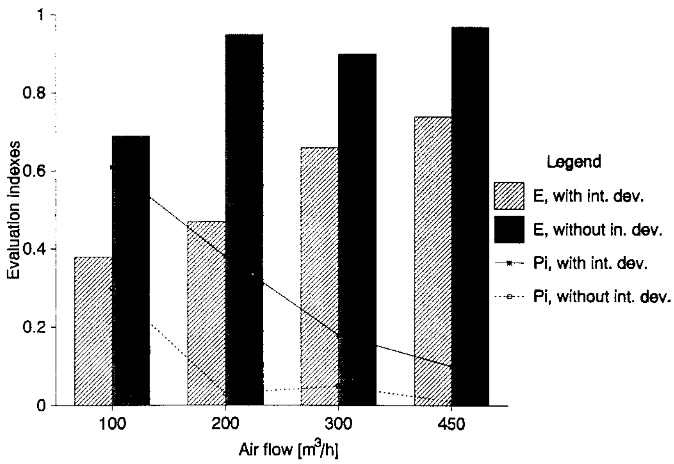

Figure 3: Efficiency coefficient and pollution index

Preliminary Conclusions

The choice of the testing procedure, especially the use of the interference device, has to be done carefully. Further research is needed, probably including measurements in occupied situations in order to have a better understanding of the effect of occupancy. Moreover it seems that various possibilities for expressing the performance exist and that perhaps more than one index should be used.

It is worthwhile to mention that the BBRI has created a working group on kitchen hoods in which the majority of Belgian manufacturers and distributors participate. The results of the various experiments (including in situ measurements of noise level and air flow rates) are discussed in this working group.

Acknowledgements

We would like to thank the Belgian Institute for Encouragement of Scientific Research in Industry and Agriculture (IWONL-IRSIA) which supported this research. Moreover, the discussions with CEN TC 156 WG 2 members and with H Caubergh and I Pepels from Caubergh Engineering were very helpful.

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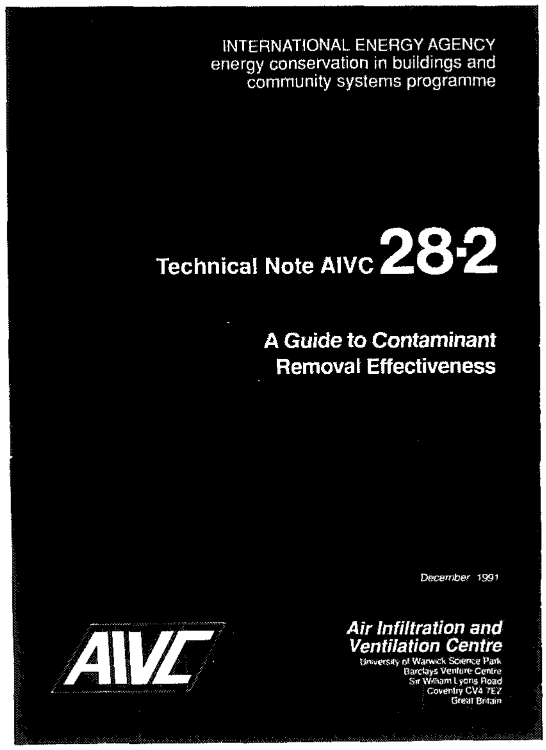
New Technical Note from the AIVC

Technical Note 28.2

A Guide to Contaminant Removal Effectiveness

by Corine Brouns and Bob Waters
Coventry Polytechnic, Great Britain

The main objective of this report was to provide an introduction to the subject of contaminant removal effectiveness. Existing literature in this subject area is limited, and tends to be very difficult for a newcomer to understand. In recent years, a number of parameters have been defined in order to quantify contaminant removal effectiveness, but not all authors have used the same names or symbols for similar parameters, or derived them in the same way. The usefulness and applicability of the various parameters has not been presented in a comprehensive way in a comparative format and, although the measurement of these parameters has been reported by several authors, there are few published summaries of the most suitable methods. Finally, none of the existing parameters provide a relative measure of contaminant removal effectiveness in the same way as air change efficiency, which provides a comparison with piston flow. Therefore, this report aims to show the origins of the concepts used, provide proofs of the basic formulae and suggests standard symbols and definitions. It also recommends methods of measurement with particular reference to difficulties and possible errors, and investigates the possibility of deriving a contaminant removal effectiveness parameter which will provide a measure of the performance of a ventilation system in removing a contaminant relative to some reference system.



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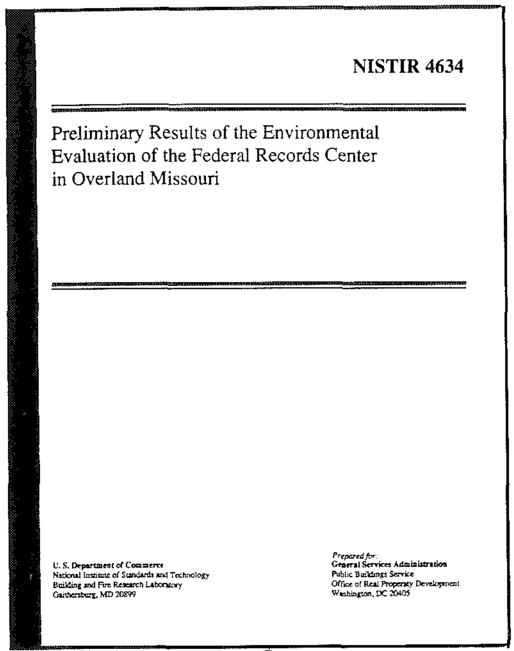
Preliminary Results of the Environmental Evaluation of the Federal Records Center in Overland Missouri

Andrew K Persily, W Stuart Dols, Steven J Nabinger, Severine Kirchner
NISTIR 4634, US Department of Commerce, July 1991

The National Institute of Standards and Technology (NIST) is studying the thermal and environmental performance of new federal office buildings for the Public Buildings Service of the General Services Administration (GSA). This project involves long-term performance monitoring both before occupancy and during early occupancy in three new office buildings. The performance evaluation includes an assessment of the thermal integrity of the building envelope, long-term monitoring of ventilation system performance, and the measurement of indoor levels of selected pollutants. This report describes the effort being conducted in the second of the three building, the Federal Records Center in Overland Missouri, and presents preliminary measurement results from the building. The infrared thermographic inspection of the Overland Building did not reveal any significant thermal defects in the building envelope, though the existence of air leakage and thermal bridging was noted. The whole building pressurization test showed that the building is quite leaky compared to other modern office building. The measured radon concentrations were 2 pCi/L or less on the B2 level, and less than or equal to 0.5 pCi/L on the other levels. Formaldehyde concentrations ranged from 0.03 to 0.07 ppm, below the 0.1 ppm guideline but above some levels of concern. The measured levels of volatile organic compounds were similar to those observed in other new office buildings, and the impact of building furnishings and construction activities on the VOC levels were noted. The carbon dioxide levels in the building have generally been low, as would be expected in a building with low levels of occupancy.



NISTIR 4634

Preliminary Results of the Environmental Evaluation of the Federal Records Center in Overland Missouri

U. S. Department of Commerce
National Institute of Standards and Technology
Building and Fire Research Laboratory
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IAI Indoor Air International
Quality of the Indoor Environment
DATE: April 28-30, 1992
VENUE: Athens, Greece
CONTACT: Conference Secretariat, Quality of the Indoor Environment, Unit 6, 2 Old Brompton Road, London SW7 3DQ, UK.
Tel: +44 71 823 9401
Fax: +44 81 780 9894

CIB '92 World Building Congress
DATE: May 18-22, 1992
VENUE: Montreal, Canada
THEMES: 1. New Materials and Systems, 2. Rehabilitation and Restoration, 3. Environment, 4. Globalization, 5. Computers and Robotics.
CONTACT: Congress Secretariat, CIB '92 World Building Congress, National Research Council Canada, Ottawa, Canada K1A 0R6

ISRACVE
International Symposium on Room Air Convection and Ventilation Effectiveness
DATE: July 22-24, 1992
VENUE: University of Tokyo, Japan
THEMES: Indoor airflow and pollutant diffusion analysis; definition and measurement of whole building and/or room ventilation effectiveness; specialized ventilation; conventional ventilation.
CONTACT: Professor S Murakami, Chairman of ISRACVE, Institute of Industrial Science, University of Tokyo, 7-22-1, Roppongi, Minato-ku, Tokyo, 106 Japan,
Tel: +81 3 3402 6231 ext. 2575
Fax: +81 3 3746 1449

CWE '92
First International Symposium on Computational Wind Engineering
DATE: August 21-23, 1992
VENUE: University of Tokyo, Japan
THEMES: Basic theories, turbulence models etc.; methodology of numerical simulation; flow and pressure fields around structures; wind loading on and wind induced vibration of structures; wind environment; dispersion of pollutants; modeling of natural wind; computer graphics for flow visualization; computer aided experiments.
CONTACT: Professor S Murakami, Chairman of CWE '92, Institute of Industrial Science, University of Tokyo, 7-22-1, Roppongi, Minato-ku, Tokyo, 106 Japan.
Tel: +81 3 3401 7439
Fax: +81 3 3746 1449

Roomvent '92
Air Distribution in Rooms Third International Conference
DATE: September 2-4, 1992
VENUE: Aalborg, Denmark
CONTACT: Roomvent '92, Danish Association of HVAC Engineers, Orholmvej 40B, DK-28 00 Lyngby, Denmark,
Tel: +45 42 87 76 11
Fax: +45 42 87 76 77

AIVC 13th Conference
Ventilation for Energy Efficiency and Optimum Indoor Air Quality
DATE: September 14-18, 1992
VENUE: France
CONTACT: AIVC, University of Warwick Science Park, Barclays Venture Centre, Sir William Lyons Road, Coventry CV4 7EZ, Great Britain
Tel: +44 (0) 203 692050
Fax: +44 (0) 203 416306

Energy Economy 1992
European exhibition and conference on energy efficiency and environment
DATE: September 15-17, 1992
VENUE: Maastricht, Netherlands
CONTACT: RAI Gebouw bv, Europaplein, NL-1078 GZ Amsterdam, Netherlands,
Tel: +31 (0) 20 5491212
Fax: +31 (0) 20 6464469

CIB W67 Workshop
Energy Efficiency and Ventilation
DATE: September 1992
VENUE: UMIST, Manchester, UK
CONTACT: Prof. K M Letherman, Dept of Building Engineering, UMIST, Manchester M60 1QD, UK
Tel: +44 61 200 4242
Fax: +44 61 200 4252

Indoor Air Quality, Ventilation and Energy Conservation in Buildings.
5th International Jacques Cartier Conference
DATE: October 7-9, 1992
VENUE: Queen Elizabeth Hotel, Montreal, Canada
CONTACT: Fariborz Haghighat, Centre for Building Studies, Concordia University, Montreal, Quebec, Canada H3G 1M8
Tel: (514) 848 3192
Fax: (514) 848 7965

ASHRAE IAQ '92
Environments for People symposium
DATE: October 18-21, 1992
VENUE: San Francisco, California, USA
CONTACT: Manager of Technical Services, ASHRAE, 1791 Tullie Circle NE, Atlanta, GA 30329-2306
Tel: 404/636-8400
Fax: 404/321-5478

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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 (1981) Allen, C. 'AIRGLOSS; Air Infiltration Glossary (English edition)'
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.'

IEA ANNEX REPORTS

DCV (1990) Raatschen, W (ed.) Demand controlled ventilating system: state of the art review.' Annex 18 report.
C&E (1991) Annex XIV Report "Condensation and Energy", in four volumes; 1. Sourcebook, 2. Guidelines and Practice, 3. Catalogue of Material Properties, 4. Case Studies,

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.
- 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.
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