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State-of-the-Art Review about "Demand Controlled Ventilating Systems" Completed

Willigert Raatschen, Lars Goran Mansson

Background of IEA Annex 18

In October 1987 "Annex 18" - Demand Controlled Ventilating Systems started as a project within the programme "Energy Conservation in Buildings and Community Systems" of the International Energy Agency (IEA). Ten countries are now involved in the work: Belgium, Canada, Denmark, Federal Republic of Germany (Subtask A leader), Finland, Italy, The Netherlands, Norway, Sweden (Operating Agent) and Switzerland.

Within the IEA countries, more and more attention is being paid to indoor and outdoor air quality. Outgassing of building materials together with occupant generated pollutants such as carbon dioxide (CO_2), moisture and odours are of concern.

Progress has also been made to address issues related to the air tightness of the building envelope. Experience reported from indoor air quality studies indicates that a better control of supply air flow rates and the air distribution pattern within the buildings is needed to connect the need for energy conservation with indoor air quality requirements. One of the options to maintain good indoor air quality without extensive energy consumption is to control the ventilation rate according to the needs and demands of the occupants or for the preservation of the building envelope. These are commonly called Demand Controlled Ventilating (DCV) Systems.

Objectives of Annex 18

With regard to the specific goals of Annex 18 and the ongoing research work on indoor air quality (IAQ) a Demand Controlled Ventilating System is defined in the following way:

A DCV system is a ventilation system, where the air flow rate is governed by airborne contaminants.

A DCV System can therefore be governed by a time clock control, and /or a presence control, and /or a sensor control. In the latter strategy a sensor could be activated by suitable gases such as carbon dioxide, water

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vapour or hydrocarbons to keep air quality at a desired level.

The specific objective of Annex 18 is to develop guidelines for demand controlled ventilating systems based on state-of-the-art analyses, case studies on ventilation effectiveness, and proposed ventilation rates for different users in domestic, office, and school buildings. To fulfil the objectives, the work was divided into the following subtasks:

Subtask A: Review of existing technology

Subtask B: Experimental studies

B1. Long term testing of the performance of sensors in laboratory and field

B2. Trials in unoccupied test buildings or test rooms

B3. Field trials in occupied buildings

Subtask C: Preparation of a source book on design and operation of Demand Controlled Ventilating Systems.

The activities in Annex 18 are a follow-up to the work undertaken by Annex 9 to establish minimum ventilation rates for buildings.

The working group had to restrict their work. Investigations are focussed on offices, auditoria, schools, and domestic buildings with different emphasis of the participating countries. Contaminant control is restricted to CO_2 and humidity (especially in dwellings), for which sensors are available. Furthermore, the control of odours and tobacco smoke is addressed, which is dependent on the performance of so called mixed-gas sensors which do not selectively measure one specific gas but react to non-oxidized gases. These sensors are distributed on the market with names like "air quality sensors", "tobacco smoke sensors" or "carbon monoxide sensors".

Contents of the Subtask A Report

According to the time schedule the State-of-the-Art Review, the goal of Subtask A, has now been completed. The report will be published as a Technical Note and distributed by the Air Infiltration and Ventilation Centre (AIVC) and will be available in Spring 1990. A German

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 1,000 words in length. If you wish to contribute to AIR, please contact Janet Blacknell at the Air Infiltration and Ventilation Centre.

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

An Apology: The article by James Piggins "Progress and Trends - 10th AIVC Conference" in the December edition of AIR, regrettably contained an error. The paper "An Experimental Method to Measure 3D Air Velocity" was incorrectly attributed and was in fact presented and authored by Gregory Gottschalk of the Energy Systems Laboratory, ETH Zurich in Switzerland.

translation which will be an extract of the most important points will also be available through the AIVC at the same time.

Subtask A provides an assessment of existing technologies and current knowledge about DCV systems.

The report contains 5 chapters:

Chapter 1: Contaminant levels in various building types. Ten references, representing the innumerable amount of papers on this subject, prove that depending on the ventilation strategy contaminant levels which are too high often exist. On the opposite, mainly with mechanical ventilating systems it could be shown that too much air is supplied to a space which results in excessive energy consumption.

Chapter 2: Review of international standards for indoor air contaminants

IAQ is a very complex and sensitive topic. Therefore, it has unfortunately up to now not been possible to define good IAQ in terms of concentration levels. For DCV systems it is a main question on what set points sensors should be adjusted. How developed countries address this problem in their codes and standards is the subject of this chapter. Five tables give an overview about "acceptable indoor concentration" values concerning carbon dioxide, carbon monoxide, nitrogen dioxide, formaldehyde, hydrocarbons and humidity of the countries involved in Annex 18, as well as threshold values from ASHRAE and WHO.

Chapter 3: Sensors
The first part of this chapter explains the function principle of humidity sensors, carbon dioxide sensors and mixed-gas sensors.

The second part gives an overview of the sensor market from today. A survey among 41 producing and/or distributing companies was undertaken to get an overview about available sensors for the use in DCV systems. Summarised are product information: company name, sensor type used, concentration range, accuracy, size/weight, price and remarks concerning stability, necessary calibration, and general remarks.
Most products come from Germany and Switzerland. Although tried it was not possible to screen the Japanese sensor market where IAQ-sensor technology seems to be most advanced.

This sensor survey is to our knowledge with regard to IAQ the most comprehensive one which exists.

Chapter 4: Summary of findings.
A literature survey was undertaken concerning measuring results and knowledge about DCV systems to establish the base for the future work of Annex 18. More than 30 papers of the last 10 years were reviewed with respect to DCV-relevant information. Most papers deal with CO_2 control, some with tobacco smoke and odour control and 3 papers with humidity control in dwellings. First information could be collected on different sensor types, on problems with sensor location, and ventilation efficiency. Also addressed is the broad range of reported possible energy savings.

Chapter 5: Conclusions
In the conclusions all gathered information is summarised and weighed due to the subjective and current knowledge of the working group.

The subchapter "Indoor Air Quality" addresses which contaminants are/aren't suitable to control IAQ with respect to the building type.

The subchapter "Sensors" states the capabilities of the various sensor types and defines the gaps of knowledge at present and leads the way to further research in this field.

The subchapter "Demand Control Strategy" summarises influencing factors which have to be considered for the design of a DCV system.

The subchapter "Benefits" states the dubiety of reported energy savings and the problematic nature when comparing different ventilation strategies with regard to energy consumption and indoor air quality.

Contacting the Air Infiltration and Ventilation Centre

By telephone: (0203) 692050

By telefax: (0203) 416306

By telex: 312401 sciprk g

Mass Flow for AIDA

Correspondance from

Larry Palmiter, Senior Scientist, Ecotope Inc, Seattle, USA

The Air Infiltration Development Algorithm (AIDA) published in the December 1989 issue of "AIR" is strictly speaking only valid for mild climates, since the less accurate volumetric form of the flow equation is used. The purpose of this note is to suggest changes to the original algorithm as presented in Appendix 1 in order to solve for mass air flow.

In some regions it is also useful to link air density to elevation above sea level, rather than include it as a fixed value. At the elevation of Denver, for example, absolute pressure is reduced by 20% thus, for a given temperature difference, stack pressure is also reduced by 20%. A variable density modification has therefore also been introduced. The necessary modifications to the Code are presented in Table 1

Where
Y = Absolute Pressure (Pa)
D = Outside Air Density (kg/m^3)
G = Inside Air Density (kg/m^3)

With these adjustments, the model will give the correct flows for all temperatures and elevations.

Table 1 Modifications to AIDA for Mass Flow and Density Variations

```
175 INPUT "Elevation above sea level (m)   = ",Z
176 Y=101325!*(1-.0065*Z/288.15)^5.2559
195 D=Y/(287.044*(E+273.15))
196 G=Y/(287.044*(I+273.15))
```

The stack pressure calculation can then be simplified to:

```
260 S(J)=-9.80665*H(J)*(D-G)

410 IF O>0 THEN F(J)=C(J)*(ABS(O)^N(J))*D
415 IF O<0 THEN F(J)=C(J)*(ABS(O)^N(J))*(-G)
505 Q=Q/D
```

Using a larger and more sophisticated version of the same one-zone flow model, we have found that eleven vertical holes, equally spaced, are required to model the stack flow through a uniformly porous wall to an accuracy of 3-4%. The four faces of a simple building then require 44 holes to obtain reasonable accuracy. Use of only three or four holes to model the walls can result in errors of 100% or more. You may wish to share these guidelines with users of your program.
(Full details of AIDA are available from Martin Liddament at the AIVC.)

Appendix 1 Volumetric flow form of AIDA for pc operators

```
10 REM SET N
15 CLS
20 PRINT "Welcome to AIDA"
30 PRINT "Air Infiltration Development Algorithm"
40 PRINT "M Liddament - AIVC -1989"
50 DIM H(10),C(10),N(10),P(10),T(10),W(10),S(10),F(10)
55 PRINT:PRINT:PRINT
60 D=1.29 : REM Air Density at 0 Deg C
70 PRINT "Enter Building Data:"
80 INPUT "Building Volume (m3) = ";V
85 PRINT:PRINT:PRINT
90 PRINT "Enter Flow Path Data:"
100 INPUT "Number of Flow Paths = ";L
110 FOR J=1 TO L
115 PRINT:PRINT:PRINT
120   PRINT "Height (m)(Path";J;")  = ";: INPUT H(J)
130   PRINT "Flow Coef (Path";J;")  = ";: INPUT C(J)
140   PRINT "Flow Exp  (Path";J;")  = ";: INPUT N(J)
150   PRINT "Pres Coef (Path";J;")  = ";: INPUT P(J)
160 NEXT J
165 PRINT:PRINT:PRINT
170 PRINT "Enter Climatic Data:"
175 PRINT:PRINT:PRINT
180 INPUT "Ext Temp (Deg C)     =";E
190 INPUT "Int Temp (Deg C)     =";I
200 INPUT "Wind Spd(Bldg Ht)(m/s)=";U
210 REM Pressure Calculation
220 FOR J=1 TO L
230   REM Wind Pressure Calculation
240   W(J)=.5*D*P(J)*U*U
250   REM Stack Pressure Calculation
260   S(J)=-3455*H(J)*(1/(E+273)-1/(I+273))
270   REM Total Pressure
280   T(J)=W(J)+S(J)
290 NEXT J
300 REM Calculate Infiltration
305 CLS:PRINT:PRINT:PRINT
310   PRINT "Calculation in Progress"
320 R=-100
330 X=50
340 Y=0 350 B=0
360 R=R+X
370 FOR J=1 TO L
380   Y=Y+1
390   O=T(J)-R
400   IF O=0 THEN F(J)=0: GOTO 430
410   F(J)=C(J)*(ABS(O)^N(J))*O/ABS(O)
420   B=B+F(J)
430 NEXT J
440 IF B<O THEN R=R-X: X=X/2: GOTO 350
450 IF B<0.0001 THEN GOTO 470
460 GOTO 350
470 Q=0
480 FOR J=1 TO L
490   IF F(J)>0 THEN Q=Q+F(J)
500 NEXT J
505 PRINT:PRINT:PRINT
510 REM SET F5
520 PRINT "infiltration rate (m3/s) = ";Q
530 A=Q*3600/V
540 PRINT "air change rate (ach)    = ";A
545 PRINT:PRINT:PRINT
550 GOTO 170
```

AIVC Numerical Database

The Objectives and Expected Contents

James Piggins, AIVC

The Air Infiltration and Ventilation Centre is currently finalising the detailed work program for its Numerical Database. This is being developed in response to the need to establish a core of numerical data, suitable for model validation, the modelling of real buildings, assessment of standards, the effects of new building methods and the use of differing ventilation systems.

Substantial amounts of data have been collected by researchers in both IEA projects and others, but these are generally uncoordinated, since they form the basis of individual research programs. Unfortunately, once this work is completed the raw data is rarely published, leading to the loss of much useful information.

The aim of the AIVC's Numerical Database is to take the original core data, from as many sources as possible and present it in an easily accessible form, for researchers to use. It is therefore designed to compliment the Centre's bibliographic database AIRBASE (1).

The core data types incorporated in the database will include the following:
Basic climatic data: Sample weather data from as many countries as possible to allow comparisons of building performance between climates, a factor which is becoming more important as wider international standards for construction are established. These should also assist in the selection of appropriate technology transfers, as individual countrys' standards for construction in airtightness, ventilation and energy efficiency are updated.
Standards: As standards are updated and comparisons are drawn, researchers will need easy access to the required information much of it numerical. The numerical database will work hand in hand with the Centre's written reports on national standards, to allow direct rapid comparisons between requirements.
Wind Pressure Coefficients and Associated Algorithms: This data is available from a number of different sources, but by its very nature is complex for all but the most simple building shapes. Data for a basic low square building (aspect ratio: 1:1) or, a low rectangular building (aspect ratio: 2:1) has been published in the AIVC's Calculation Techniques Guide(2). Data for other shapes has been published, but is scattered throughout numerous publications and is often incomplete. This data will be collated into the numerical database where it should be possible to combine a number of similar data sets to produce further unified data for many building configurations. Complete data sets for real build-

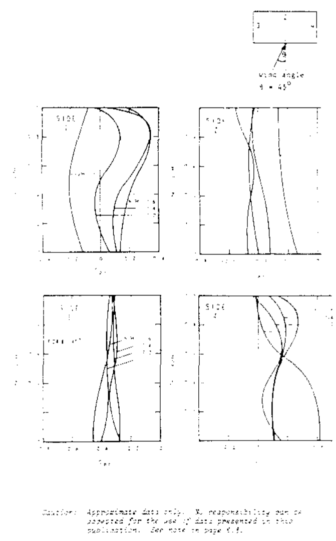


Figure 1: Data from the AIVC Calculation Techniques Guide

ings will also be included with Cp data as well as dimensional data allowing the whole data set for a building to be used in a modelling exercise.
Whole Building Leakage Values: These will be stored and linked to files containing any details of the buildings they refer to. This should eventually lead to a large database of values which can be analysed for building type and changing trends over time. Comparisons with required standards and future recommendations for standards, along with comparisons between countries and climates, will thus be possible.
Typical Component Leakage Values: As for the Wind Pressure Coefficients a number of these leakage values have been published in the Calculation Techniques Guide (2). This data will be entered into the database and extended, as and when additional data is available. These values will be essential for the modelling of newly designed buildings, and where the measurement of component leakages of an existing building is impractical.
Air Change Rate Measurements: These will be kept as for the whole building leakage data linked to a building description file, which will allow analysis of changing trends in the building stock for individual countries. Comparisons between countries and the effects of local standards will also be possible.

Interzonal Air Flow Data: In addition to gross air change rate data, interzonal flow rate data will also be stored. This will require far more detailed information on the building concerned and the prevailing weather conditions, both of which will be stored in related files. This type of more detailed information will be of use primarily for model validation purposes. It may also be useful, when comparing the effectiveness of various types of purpose provided passive, and mechanical ventilation systems.

Ventilation Effectiveness and Air Flow Patterns Data: This data will be of use to designers of new buildings and ventilation systems. Air flow pattern data will also be vital for individual room model validation.

Pollutant Transport: Data concerning the migration of pollutants will allow modellers and designers to assess the effectiveness, and possible problems associated with old and new building methods and ventilation systems. It will be possible to compare the properties of various pollutants related to their different sources, chemistries, densities, and relative absorption/breakdown rates. Data on occurrence of different pollutants in differing structures and countries, and the effect on and of occupant behaviour will also be available.

Occupant Effects on Air Change Rates and Energy Usage: The effect of occupant behaviour is also closely related to the real energy usage of buildings. How ventilation systems alter occupant behaviour due to their real or perceived qualities can be critical in the energy equation. The close interaction between the building fabric and its internal/external environments varies from country to country according to local lifestyles and prevailing weather conditions. The numerical database will allow these complex interactions to be assessed and compared between building styles, ventilation systems, countries, and their applied standards.

Ventilation Heat Loss: Throughout the IEA member states, energy conservation measures have made ventilation heat losses increasingly critical in the energy equation. The large amount of data collected will assist in the recommendation of appropriate measures according to prevailing climate and building practices.

Cost Effectiveness Data: The cost effectiveness of different ventilation strategies varies enormously, according to climate, building type, ventilation system, and occupant behaviour. The requirements for pollutant control are also vital in this assessment. Appropriate balances have to be struck between cost and effectiveness for any building/ventilation system combination. The numerical database will aid in this assessment, by its contributions in all of the above described categories. Ultimately however the least cost alternatives will prevail. The correct assessment of these options will be vital both from health and energy considerations. It is hoped that the database will provide a valuable contribution in this assessment.

Data for the database is already being received from several sources. These include multizone leakage and ventilation data from the LESO building (Figure 2) collected for Annex 20 by EPFL in Lausanne,Switzerland (3). This data will be included in the numerical database as a set of files describing the whole building. Typical data from any of these files may eventually be combined into summary files, or the whole file used for model validation purposes. The climate data set may also serve a useful function as being typical for its location.

Figure 2: The LESO building, EPFL Lausanne, Switzerland

An important aspect of the database software is its data processing capabilities. Compatible data can be extracted from any part of the database and output in an acceptable form. A number of model interface programs will be made available to produce output files compatible with common models used at the Centre. The flexibility of the chosen software will also allow users to design their own output modules. These can be fully menu driven programs, operating as a shell over the database software itself. Similar modules can be developed for data output into most commonly available spreadsheet formats. Quality reports of selected data can also be produced directly from the database. As well as being available as a computer package, selected parts of the numerical database will be published as a new AIVC Guide. Any relevant portions of the existing Calculation Techniques Guide will be updated. The database will also be used as source data for future AIVC Guides and Technical Notes.

References:

1) See AIRBASE - Now available for your PC, later in this magazine.

2) Air Infiltration Calculation Techniques-An Applications Guide, Martin Liddament, June 1986, The Air Infiltration and Ventilation Centre.

3)Weather and aeraulic data set for validation. The LESO Building. Part 1: Content of the data set. February 1989. J.-M. Furbringer, R. Compagnon. Ecole Polytechnique Federale De Lausanne.

The Design and Testing of a Calibration Chamber Used in the Development of an AC Pressurization Apparatus

R M Alkhaddar, J Dewsbury and R Orlowski

1-Introduction

2-Design of the Calibration Chamber

3-Testing of the Chamber

1-Introduction

AC pressurisation is a method for measuring the airtightness of buildings. This technique, which is also called the infrasonic method, employs a reciprocating piston or bellows to impose a sinusoidal small change in volume inside the building being tested at a frequency in the range of 0.1-10Hz. A fluctuation in the internal pressure is produced. From these two factors, the frequency and the pressure reading, a measure of the airtightness of the building can be deduced. With AC pressurisation it should be possible to measure airtightness at lower pressure differences than with fan pressurization, as there should be less interference by wind and stack effects.

The aim of this paper is to describe the design and testing of a calibration chamber for use in the development of an AC pressurisation instrument. The instrument will subject the test rig to pressure fluctuations of around 1-10Pa, at frequencies of the order of 0.1-10Hz.

2-Design of the Test Chamber

The chamber is required to be much more airtight and stiffer than normal buildings, to allow calibration of the AC pressurisation apparatus. The apparatus is to be calibrated using leaks and flexible elements of realistic size, but of simple and independently known characteristics. It was decided to design a 2.5m wide, 2.5m high and 6m long steel tank with a sealable door as the required calibration chamber, so that the apparatus and realistic leaks can be accommodated, and the chamber moved to enable both laboratory and field tests. The design of the tank can be divided into three stages as follows.

The first stage consisted of performing simple deflection calculations to establish an approximate indication of the maximum deflection at the tank plate centres. Different plate thicknesses and different configurations of outside stiffeners were used in order to utilize the best combination. Table(1) shows the different values of deflection and the corresponding pattern of stiffeners. On the conclusion of this analysis it was decided to choose a plate thickness of 8mm and pattern 4, see Table(1), of stiffener distribution. All stiffeners were chosen to be 102mm x 51mm mild steel channel. The front and back faces of the tank were provided each with two vertical stiffeners placed 0.7m from the side of the tank, see Figure(1). Also at the middle of each of the six faces of the tank a horizontal stiffener was attached, i.e. 1.25m above the base, shown in Table(1) pattern(4) and in Figure(1). After establishing the basic shape of the test rig, a more accurate deflection analysis can be performed which is stage two in the design procedure.

Table(1)- STIFFENERS POSITIONS AND THE RESULTING DISPLACEMENTS WHEN SUBJECTED TO A 50Pa LOAD. TANK DIMENSIONS ARE (6m x 2.5m x 2.5m)

	Pattern(1) No Stiffeners		Pattern(2) Divided to 2.5x2.0m panels		Pattern(3) Divided to 1.25x2.0m panels	
mm	Displ. cm	Vol. of displ.cm	Displ. cm	Vol. of displ.cm	Displ. cm	vol. of displ.cm
3	0.0323	0.646	0.0094	0.19	0.0018	0.043
6	0.0074	0.148	0.0022	0.044	0.0004	0.0082
8	0.004	0.08	0.0012	0.024	0.00023	0.0045

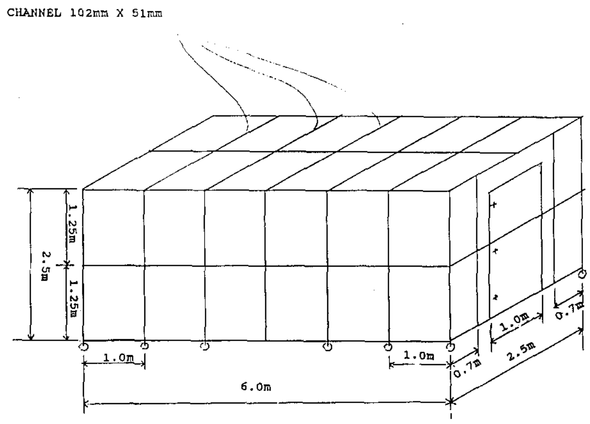
	Pattern(4) Divided to 1.25X1.0m panels		Pattern(5) Divided to 1.25X0.75m panels	
	Displ. cm	Vol. of displ.cm	Displ. cm	Vol. of displ.cm
3	0.00061	0.0142	0.00024	0.0048
6	0.00014	0.0033	0.00005	0.0011
8	0.000076	0.0018	0.00003	0.0006

In stage two the finite element method was used to predict the magnitude of any deflection that occurs at any point on the tank surface. This was done by using the PAFEC package on a Prime mainframe computer. Two values of pressure were used, 10Pa and 20000Pa. The 10Pa pressure yielded a maximum deflection of 0.00242mm, and the higher pressure resulted with a maximum deflection of 4.84mm. Both these values are considered to be very small. However the above analysis was done on the assumption that the stiffeners supporting the plates are rigid and not subject to any movement which is not completely true. Therefore a further run was conducted on one of the stiffening beams, with again pressures of 10Pa and 20000Pa. This resulted in a maximum deflection of 0.0127mm at 20000Pa, assuming fixed ends, which is negligible compared to the maximum deflection of the plate.

The third and final stage of the tank design was to calculate the natural frequencies of both the tank itself and the enclosure inside it. The natural frequencies of the tank were estimated using again the finite element package. This resulted in fundamental frequencies of the order of 58-65Hz for the different modes of vibration. These frequencies are well above the expected operating frequency range of 0.1-10 Hz. The estimation of the natural frequency (or resonant frequency) of the air inside the tank was carried out for two cases, one with the tank door open and the other with the door closed. The first case had a calculated frequency of 53Hz and the second case two resonant frequencies of approximately 28Hz and 69.5Hz respectively. All the foregoing frequencies are again higher than the operating range of frequencies to be applied during experimentation.

3-Testing of the Chamber

The first requirement that the tank should satisfy is being airtight when the door is closed. To meet this requirement the tank is of all-welded construction, and when the door is closed it compresses a rubber seal. In order to check the tightness of the tank, or seal, against leaks it first was pressurised to a pressure of 3psi at the manufacturer's works and was left for three days; a pressure reading was taken daily, and no apparent change in the reading was found. After delivery two further pressurisation tests were carried out to check the airtightness. The first was done by using fan pressurisation which failed to detect any leaks in the tank. The second pressure test was done by subjecting the tank to an internal pressure of 20000Pa and leaving it for a period of 48 hours. The pressure decay was measured by an electronic manometer which was connected to a chart recorder. Over the 48 hour period the chart showed slight decreases in the pressure followed by slight increases, see Table(2). This can be attributed to the temperature differences between day and night. The average rate of loss of pressure was so low that the tank can be considered airtight at the working pressure of 1-10Pa.



Figure(1)- A SKETCH OF THE CALIBRATION CHAMBER

Table(2)-PRESSURE DECAY IN THE TANK OVER A PERIOD OF 48 HOURS. THE TANK IS PRESSURISED TO 19.8kPa PRESSURE.

Time (Hrs)	Pressure (kPa)
0	19.8
7	18.4
14	17.2
23	1[illegible].4
33	16.6
48	16.8

Table(3)-PLATE AND STIFFENING BEAM DISPLACEMENT WHEN THE TANK IS SUBJECTED TO A 20kPa PRESSURE AND THEN DEPRESSURISED.

A-) Plate Displacement

Pressure (kPa)	Displ. (mm)
0	0
6.62	2.68
11.77	4.87
17.23	7.02
20.00	8.02
17.23	7.00
11.77	4.90
6.62	2.69
0	0

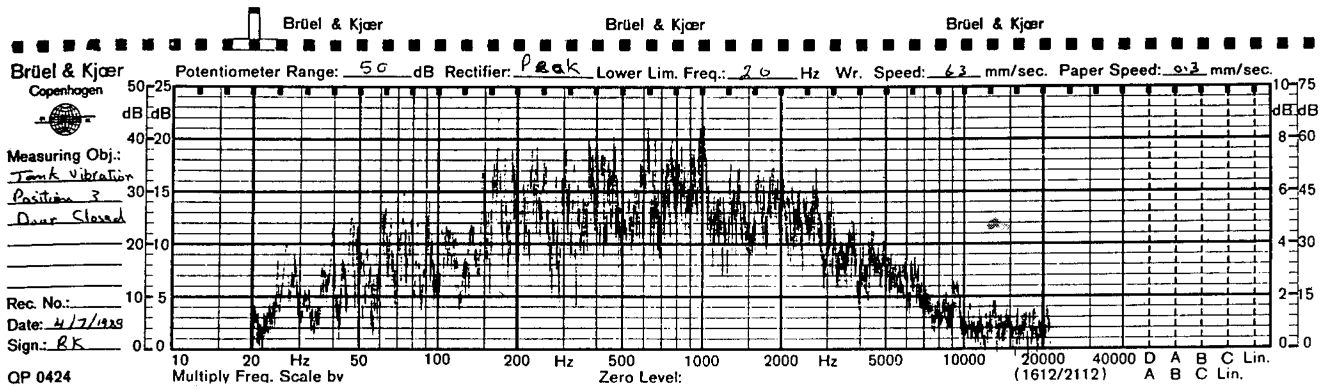
B-) Stiffening Beam Displacement

Pressure (kPa)	Displ. (mm)
0	0
6.62	0.95
11.77	1.7
17.27	2.57
20.00	2.96
17.23	2.55
11.77	1.69
6.62	0.97
0	0

The next step was to measure the actual deflection in the tank plate during pressurization and compare this with the prediction from the finite elements method. The measurements were done by using dial gauges mounted on the test rig during pressurisation and depressurizstion. It can be seen from Table(3) that at 20000 Pascals a deflection of 7.5mm resulted at the centre of one of the plates and a deflection of 2.9mm at the centre of one of the stiffeners. These values are higher than those found by the finite element method, which is believed to be due to the incorrect assumption of fixed beam ends. On the basis of the measured deflections at 20000Pa, the change in volume of the tank from 0 to 10Pa is estimated to be about 0.25 litres, which is much less than the approximately 50 litres displacement of a practical AC pressurisation device.

The final step in the validation procedure, was to measure the natural frequencies of the tank using a frequency generator. The equipment used consisted of a B&K frequency generator connected to a loudspeaker, through an amplifier, and an accelerometer connected to a vibration meter which in turn is connected to a chart recorder. Two series of tests were performed, one with the tank door open and the other with the door closed. Each series consisted of seven runs at different locations on the centres of the tank plates and stiffening beams. No significant difference between the two series of the tests was detected and also both of them confirmed the finite element results, see Figure(2) for a sample run. In all tests resonances in the tank occurred at frequencies well above the operating frequencies of the AC pressurisation instrument.

In conclusion, it is believed that the calibration chamber will be well suited for the development of an AC pressurisation system for measurement of airtightness at low pressure differences.



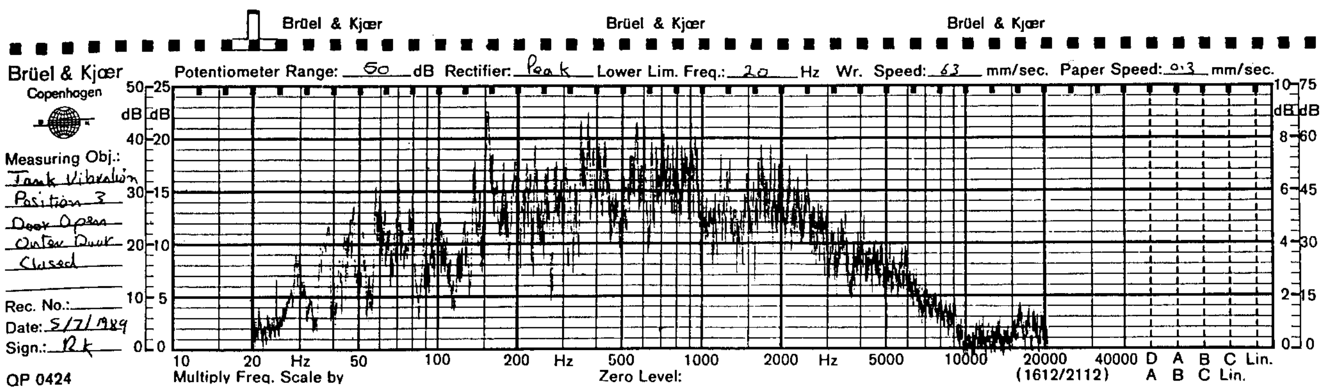


Fig. 2 SAMPLE RUNS FOR THE NATURAL FREQUENCY RESULTS OF THE TEST RIG

AIRBASE - Now Available For Your PC

Airbase, the AIVC's bibliographic database is now available as a PC version. This revised database uses Archivist software, from Oxford University Press and is available from the Air Infiltration and Ventilation Centre, complete with software, for £115. Hardware requirements include at least 7.5 Mb of hard disk space, DOS 3.1 or above and an INTEL 8086 processor or above. It should therefore operate on almost any of the common IBM clones. It also operates efficiently on portable PC's thus making it extremely mobile.

Almost all the features of the previous AIRBASE are retained including "free text" searching on the entire database text on the searching of selected fields. Each entry begins with a title field, followed by author, bibliographical, abstract and keyword fields.

The software is "menu" driven and is exceptionally straightforward to use. Starting with a single search term, eg Radon, the computer develops a retreived list of all entries containing this term. The search may then be systematically narrowed or widened by keying in the appropriate function key and entering a new term. Searching is very rapid and normally takes a few seconds. Sometimes it is advantageous to search on a particular field only(eg the Author field), in which case the search time is greatly reduced. At any stage, entries may be displayed on the screen, printed out or stored in an output file for later use. Full instructions with sample searches are provided with the AIRBASE documentation. In order to prevent accidental corruption of AIRBASE, it has been write-protected. However, the Archivist software may be used for the development of further databases as many as may be required by the user.

Subject Coverage

AIRBASE currently contains abstracts of over 3500 articles related to air infiltration and ventilation. In addition to articles scanned from the journals, it also contains references of specialist reports such as written documents and internal publications. Articles are drawn from sources worldwide. In total the topics covered by AIRBASE may be subdivided into nearly 200 subject areas, with broad themes covering energy aspects, indoor air quality, occupancy effects, ventilation strategies, standards, theory, calculation techniques, measurement methods and case structures.

At a future date, the AIVC Current Survey of Research will also be added as a parallel database.

Updating Airbase

AIRBASE is updated regularly with approximately 500 entries being added each year. New entries are published in the Centre's quarterly bulletin "Recent additions to AIRBASE". Software updates may be purchased as needed at £20 for each update.

Library Service

Every item referenced in AIRBASE is available from the Centre's library service and may be requested by completing a literature request form. The AIRBASE search service continues to be available and the Centre's staff will be pleased to conduct your search for you.

Obtaining Airbase.

AIRBASE is available directly from the Air Infiltration and Ventilation Centre to participating countries only. It may be orded by completing the form below and returning it to the AIVC. AIRBASE comes complete with documentation and Archivist software.

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Details of source of article

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AIRBASE contains references from 1920 onwards, and searching can be restricted to a range of dates

Abstract

Each entry is accompanied by an informative English language abstract. The AIVC's free text retrieval system can search for significant words in the abstract

#NO 3486 To insulate a basement

AUTHOR Quaid M

BIBINF USA, Home Energy, May-June 1989, pp 12-15, 3 tabs, 1 fig, 9 refs. #DATE 00:05:1989 in English

ABSTRACT The article discusses available methods of insulation (E.G. foundation, exterior, interior.) and addresses, amongst other issues, the cost-effectiveness of foundation insulation, both as a **retrofit** in existing homes and as a component of new construction. The results and conclusions reached in the literature are provided by numerous studies undertaken over the past few years.

KEYWORDS cost effectiveness, insulation, foundation, **retrofit**

Titles

Titles are given in both the original language and English

Language

AIRBASE currently covers 15 different languages and English translations of some papers are held by the AIVC's library

Keywords

Keywords from a thesaurus of terms have been added to each entry to improve the accuracy of searches

Highlighting

A search on "retrofit" would produce a list of records including this sample. Most original articles are available from the AIVC's library

New Technical Notes from the AIVC

AIVC Technical Note 27

Infiltration and leakage paths in single family houses - a multizone infiltration case study

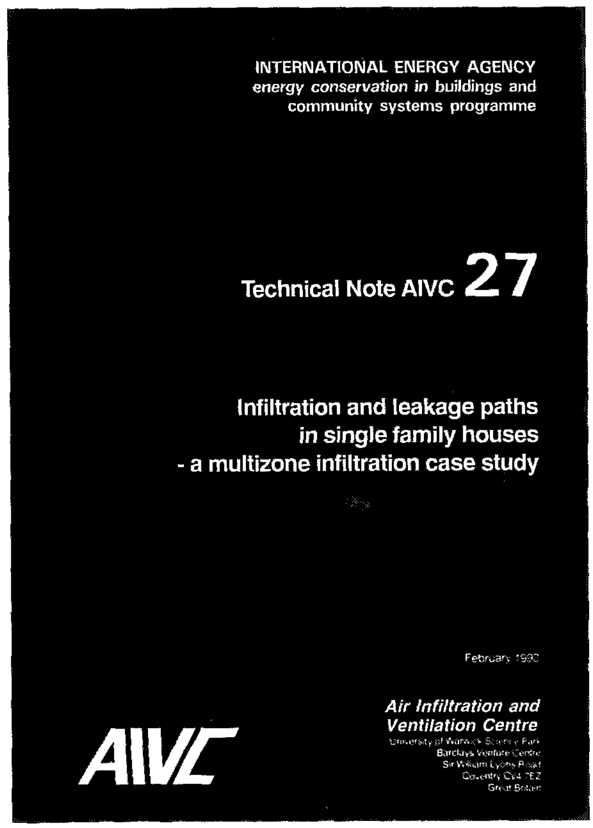
by Mark Bassett, BRANZ, New Zealand

Multizone air flow models play an essential part in calculating air flows that transport heat, contaminants and moisture through the occupied spaces and construction cavities in buildings. They have the potential to replace time-consuming and difficult to perform tools in building design.

The accuracy and applicability of single zone infiltration models has been examined in more detail than is the case for models in a multizone role. AIVC Technical Note 11 examined the accuracy of 10 models against single zone data sets and concluded that agreement within 25% could generally be expected when complete details of climate, location of leakage openings and wind pressure coefficients were available. The same arbitrary 25% criteria were applied to comparisons between measured and calculated data in this report. There have been a number of occasions where measured and calculated multizone air flows have been compared. Perera and Warren compared air flows calculated with the computer program BREEZE with tracer gas measurements in a multiple-zoned domestic building. Using wind pressure coefficients derived from wind tunnel studies, and some area weighting of background leakage openings, favourable agreement was achieved. Similarly, Etheridge and Alexander found satisfactory agreement between the British Gas multizone model and measured air flows using measured wind pressure coefficients. More recently the COMIS group have undertaken extensive development and validation of multizone models.

The objectives of this work were as follows:

1 To organise measured building air tightness and local wind exposure data into data sets for numerically modelling infiltration and interzone air flows.



INTERNATIONAL ENERGY AGENCY
energy conservation in buildings and community systems programme

Technical Note AIVC 27

Infiltration and leakage paths in single family houses - a multizone infiltration case study

February 1990

Air Infiltration and Ventilation Centre

2 To calculate air flows corresponding to measured wind speeds and zone temperatures, and compare these with data measured using a multitracer system.

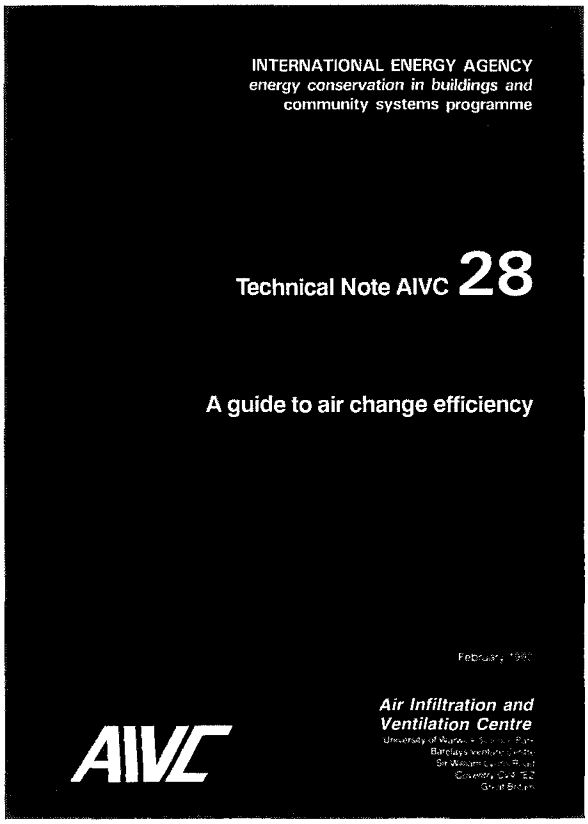
3 To define the level of accuracy achieved and the assumptions made, and to identify further critical physical parameters that are required for a more testing validation of multizone models.
Over recent years many new ventilation systems have been introduced in order to meet increasing air quality

AIVC Technical Note 28

A guide to air change efficiency

by Helen Sutcliffe, Coventry (Lanchester) Polytechnic, UK

The main objective of this report was to provide a concise introduction into the subject of air change efficiency. Existing literature in this subject area is extensive, but it tends to be very detailed and is difficult for a newcomer to understand. Different authors also use different symbols and/or different definitions for the same concepts, which tends to confuse the reader. Little has been produced covering the basic ideas and concepts behind some of the terms used. Therefore this report aims to show the origins of the concepts used, provide proofs of the basic formulae and suggests standard symbols and definitions.
Sandberg and Skaret differentiate between the terms air change efficiency and ventilation efficiency. Air change efficiency is a measure of how effectively the air present in a room is replaced by fresh air from the ventilation system whereas ventilation efficiency is a measure of how quickly a contaminant is removed from the room. This report covers only air change efficiency and related concepts.



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AIVC 11th Annual Conference

Ventilation System Performance

Tuesday 18th - Friday 21st September 1990, Hotel Villa Carlotta, Belgirate, Northern Italy

Preliminary Notice

Over recent years many new ventilation systems have been introduced in order to meet increasing air quality and comfort requirements in both the homes and work places. The objective of the AIVC's 11th Annual Conference is to focus on the performance of modern systems. Both natural and mechanical systems will be covered with special emphasis on:

- Design
- Air Quality and Health Requirements
- Energy Effectiveness
- Commissioning
- Performance and Reliability
- Maintenance
- Case Studies

The conference fee will include full board accommodation on the conference dates.

To give us some idea of the number of likely attendees, please would persons who may be attending return the following form to the AIVC. This application is not binding.

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Book Review

Wind pressure on low-rise buildings. An air infiltration analysis based on full-scale measurements.

By Jan Gusten

Publication 1989:2 Division of Structural Design Chalmers University of Technology Sweden, Gothenburg 1989 ISSN 0281 1863

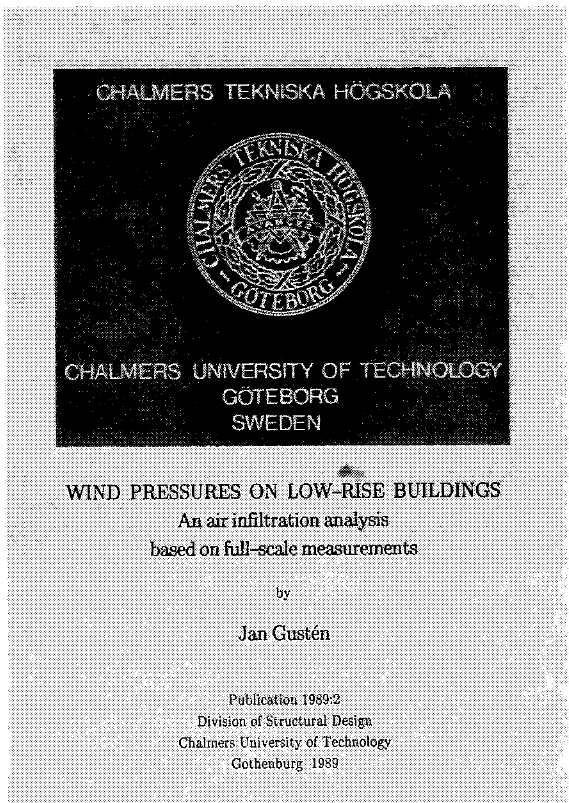
The work presented in this thesis, carried out at the Division of Structural Design at Chalmers University of Technology, is based on results from a number of research projects, sponsored by the National Swedish Council for Building Research.

The air flow around a building has an influence on the pressure distribution over the building envelope. Observation of the mean wind pressures shows that surfaces are divided into pronounced zones of positive and negative pressure. The pressure distribution, in combination with an imbalance between the exhaust and supply air flow rate, can give rise to undesirable pressure conditions. Estimation of the air exchange rate, based on measured leakage characteristics and mean pressures over the building envelope, shows discrepancies as compared with the measured number of air exchanges. The turbulence gives fluctuating pressure components of appreciable magnitude. This fact changes the prerequisites of the ventilation for a given volume.

The wind pressure spectrum shows that the greater part of the turbulent energy is concentrated at frequencies below 1 Hz. Full-scale measurements have shown that the fluctuations, which are quantified by the calculated variance of the spectrum, are of the same order of magnitude as the mean pressure. The degree of correlation between fluctuating components of the wind pressure on different parts of the building envelope is low. Because of this, the interchange of air is at all times based on a varying pressure distribution, and the participation of different leakages is variable.

In the case when air infiltration can be expected to account for a considerable part of the total air exchange rate, the methods of calculation used should take into account the real wind characteristics and the response of the building to wind fluctuations. Otherwise, from an energy point of view, use of average pressure values can often be adequate.

The pressure in the cavity behind the facade materials depends on the external pressures over the facade. A levelling, or smoothing, of the pressure fluctuations can take place, depending on the cavity design and permeability distribution.



Chapter headings are as follows:

- Introduction
- Theoretical Analysis
- Full-Scale Measurements of Wind Pressures
- Recorded Wind Pressure Distributions
- Estimation of Air Infiltration Based on Stationary Wind Pressures
- Registered Fluctuations of Pressure Differences
- Pressure Difference Measurements as a Basis for Practical Applications
- Air Infiltration Caused by Fluctuating Wind Pressure
- Conclusions
- Outline for Further Research
- References

Forthcoming Conferences

Application of Artificial Intelligence and Robotics in Building, Architecture and Civil Engineering, Europia 2nd European Conference
March 15-16,1990 Liège, Belgium
Further details from:
Professor A. Dupagne, LEMA-ULG, 15 Ave des Tilleuls, Bât D1, B-4000 Liège, Belgium

ASME International Solar Energy Conference "Design Tools for Passive Solar and Building Energy Conservation"
April 1-4, 1990, Miami, Florida, USA
Further details from:
Dr P Monaghan, Dept of Mechanical Engineering, University College Galway, Ireland

Facilities Management International Conference "Delivering Quality and Value in Buildings in an International Market"
April 9-13, 1990, Glasgow, Scotland
Further details from:
Keith Alexander, BPRU, University of Strathclyde, 131 Rottenrow, Glasgow, Scotland G4 ONG

Indoor Air Quality and Ventilation in Warm Climates
April 24-26, 1990, Sheraton Hotel, Lisbon, Portugal
Further details from:
Secretariat, International Indoor Air Quality and Ventilation Conference, British Occupational Hygiene Society, 1 St Andrews Place, London NW1 4LB, United Kingdom Tel: 01 823 9401

ASTM Subcommittee D22.05 on Indoor Air
April 25-26, 1990, San Francisco, California, USA
Further details from:
George Luciw, ASTM, 1916 Race Street, Philadelphia PA 19103, USA

Room Vent 90 Second International Conference Engineering Aero and Thermodynamics of Ventilated Rooms
June 13-15, 1990, Oslo, Norway
Further details from:
Room Vent, c/o Norsk VVS Teknisk Forening, PO Box 5042 Maj, N-0301 Oslo 3, Norway Tel: 47 2 60 13 90

FITAT International Symposium
16-18 July 16-18, 1990, Lyon, France
Further details from:
FITAT, 34 rue de la Charité, 69002 Lyon, France Tel: 33 72 40 23 95

The 5th International Conference on Indoor Air Quality and Climate
July 29 - August 3, 1990, Metro Toronto Convention Centre, Toronto, Canada
Further details from:
Indoor Air 90 Centre for Indoor Air Quality Research, University of Toronto, 223 College Street, Toronto, Ontario, Canada M5T 1R4 Tel: 416) 978 8605

Energy, Moisture, Climate in Buildings
September 3-6, 1990, Rotterdam, The Netherlands
Further details from:
Mr G de Vries, Bouwcentrum Weena 760, P O Box 299, 3000 AG Rotterdam, The Netherlands

Ventilation System Performance
11th AIVC Conference
September 18 - 21,1990,
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Further details from:
Dr Martin Liddament, AIVC

Applications and Efficiency of Heat Pump Systems in Environmentally Sensitive Times
September 18-21, 1990, Munich, Fed.Rep. of Germany
Further details from:
Lorraine Grove - Organiser, Heat Pumps Conference, BHRA, The Fluid Engineering Centre, Cranfield, Bedford MK43 0AJ, United Kingdom

Indoor Radon and Lung Cancer:Reality or Myth?
29th Hanford Symposium on Health and the Environment
October 16-19, 1990, Richland, Washington, USA
Further details from:
Fred T. Cross, Symposium Chairman, Battelle PNL, P O Box 999, Richland, WA 99352, USA Tel: (509) 375-2976

3rd International Conference on System Simulation in Buildings
December 3-5, 1990, Liège, Belgium
Further details from:
Georges Liebecq, University of Liège Laboratory of Thermodynamics, Rue Ernest Solvay, 21, B-4000 Liège, Belgium Tel: 32-41-52.01.80

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Air Infiltration Review Quarterly newsletter containing topical and informative articles on air infiltration research and application. Unrestricted availability, free-of-charge.

Recent Additions to AIRBASE Quarterly bulletin of abstracts added to AIRBASE, AIVC's bibliographic database. Bulletin and copies of papers available free-of-charge to participating countries* only.

GUIDES AND HANDBOOKS

Applications Guide 1 (1986) Liddament, M.W. 'Air Infiltration Calculation Techniques - An Applications Guide' A loose-leaf handbook divided into six chapters covering empirical and theoretical calculation techniques, algorithms, references and glossary of terms. Available free-of-charge to participating countries* only, via your national Steering Group representative.

Applications Guide 2 (1988) Charlesworth, P.S. 'Air Exchange Rate and Airtightness Measurement Techniques - An Application Guide' A loose-leaf handbook divided into seven chapters covering air change rate, interzonal air flow and building airtightness measurement techniques.

TECHNICAL NOTES

5 (1981) Allen, C. 'AIRGLOSS; Air Infiltration Glossary (English edition)' Available free-of-charge to participating countries*. Price:£10 to non-participating countries.

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

6 (1981) Allen,C. 'Reporting format for the measurement of air infiltration in buildings' Price:£6 to non-participating countries.

10 (1983) Liddament, M,, Thompson, C. 'Techniques and instrumentation for the measurement of air infiltration in buildings - a brief review and annotated bibliography' Available free-of-charge to participating countries*. Price £15.00 to non-participating countries.

11 (1983) Liddament, M., Allen, C. 'The validation and comparison of mathematical models of air infiltration' Available free-of-charge to participating countries*. Price: £15.00 to non-participating countries.

13 (1984) Allen,C. 'Wind Pressure Data Requirements for Air Infiltration Calculations' Available free-of-charge to participating countries*. Price: £20.00 (price includes copy of TN-13.1) to non-participating countries.

13.1 (1984) '1984 Wind Pressure Workshop Proceedings'. Available free-of-charge to participating countries*. Also available to non-participating countries (see note at TN-13 above).

14 (1984) Thompson, C. 'A Review of Building Airtightness and Ventilation Standards' Lists and summarises airtightness and related standards to achieve energy efficient ventilation. Available free-of-charge to participating countries* only.

16 (1985) Allen,C. 'Leakage Distribution in Buildings' Examines those factors which can influence leakage distribution, including building style, construction quality, materials, ageing, pressure and variations in humidity. Available free-of-charge to participating countries*. Price: £20.00 to non-participating countries.

17 (1985) Parfitt, Y. 'Ventilation Strategy - A Selected Bibliography' Review of literature on choice of ventilation strategy for residential, industrial and other building. Available free-of-charge to participating countries*. Price: £20.00 to non-participating countries.

19 (1986) Charlesworth, P. '1986 Survey of current research into air infiltration and related air quality problems in buildings' Fourth worldwide survey by AIVC containing over 200 replies from 19 countries. Available free-of-charge to participating countries* only.

20 (1987) 'Airborne moisture transfer: New Zealand workshop proceedings and bibliographic review'Available free-of-charge to participating countries* only.

21 (1987) Liddament, M.W. 'A review and bibliography of ventilation effectiveness - definitions, measurement, design and calculation' Reviews definitions of ventilation efficiency and outlines physical concepts, measurement methods and calculation techniques. Available free-of-charge to participating countries* only.

23 (1988) Dubrul,C. 'Inhabitants' behaviour with regard to ventilation. This report summarises the IEA annex VIII study into the behaviour of occupants with regard to ventilation. Price: £15.00 to participating countries, £25.00 to non-participating countries.

24 (1988) 'AIVC Measurment Techniques Workshop: Proceedings and Bibliography' Workshop held at Koge, Denmark in March 1988. Available free-of-charge to participating countries* only.

25 (1989) Blacknell,J. 'A subject analysis of the AIVC's bibliographic database - AIRBASE', 6th edition Comprehensive register of published information on air infiltration and associated subjects. Available free-of-charge to participating countries* only.

26 (1989) Haberda,F and Trepte,L IEA Annex IX 'Minimum ventilation rates and measures for controlling indoor air quality.'Price £15.00 to participating countries, £25.00 to non participating countries.

CONFERENCE PROCEEDINGS

No.1 'Instrumentation and measuring techniques' 1980.

No.2 'Building design for minimum air infiltration' 1981.

No.3 'Energy efficient domestic ventilation systems for achieving acceptable indoor air quality' 1982

No.4 'Air infiltration reduction in existing buildings' 1983.

No.5 'The implementation and effectiveness of air infiltration standards in buildings' 1984.

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Proceedings of AIVC conferences numbers 1-9 are also available in microfiche form, price £75.00 per set.

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

P.F. Collet,
Technological Institute, Byggeteknik, Post Box 141, Gregersensvej, DK 2639 Tastrup, Denmark.
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Finland

***R. Kohonen,**
Technical Research Centre, Laboratory of Heating and Ventilation, Lampomiekenkuja 3, SF-02150 Espoo 15, Finland.
Tel: 358 04564742 Telex: 122972 Fax: 358-0-4552408

Federal Republic of Germany

***L.E.H. Trepte,**
Dornier System GmbH, Postfach 1360, D-7990 Friedrichshafen 1, Federal Republic of Germany. Tel: 07545 82244 Telex: 734209-0 Fax: 49-7545-84411

A. Le Marié
Projektleitung Energieforschung in de r KFA Jülich GmbH, Postfach 1913,D-5170 Jülich Federal Republic of Germany.
Tel: 02461 616977 Telex: 833556

Italy

***M. Masoero,**
Dipartimento di Energetica, Politecnico di Torino, C.so Duca delgi Abruzzi 24, 10129 Torino, Italy.
Tel: (39-11) 556 7441 Telex: 220646 POLI-TO Fax: 39 11 556 7499

Netherlands

***W. de Gids,**
TNO Division of Technology for Society, P.O. Box 217, 2600 AE Delft, Netherlands, Tel: 015-696026 Telex: 38071 Fax: 015-616812

New Zealand

***M. Bassett,**
Building Research Association of New Zealand Inc (BRANZ), Private Bag, Porirua, New Zealand.
Tel: 04-357600 Telex: 30256 Fax: 356070

Norway

****J.T. Brunsell,***
Norwegian Building Research Institute, Box 322, Blindern, N-0314 Oslo 3, Norway. Tel: 02-46-98-80 Fax: +47-2-699438

H.M. Mathisen,
SINTEF,Division of App Thermodynamics, N-7034 Trondheim, Norway.
Tel: 7-593870(010 47) Telex: 056-55620

Sweden

***J. Kronvall,**
Lund University, P.O. Box 118, S-22100 Lund, Sweden.Tel: 46 107000 Telex: 33533 Fax: 46 10 47 20

F. Peterson,
Royal Institute of Technology, Dept. of Heating and Ventilating, S-100 44 Stockholm, Sweden.
Tel: 08-7877675 Telex: 10389

Switzerland

***P. Hartmann,**
EMPA, Section 175, Ueberlandstrasse, CH 8600 Dübendorf, Switzerland.
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Oscar Faber Consulting Engineers, Marlborough House, Upper Marlborough Road, St. Albans, Herts, AL1 3UT, Great Britain. Tel: 01-7845784 Telex: 889072 Fax: +1-7845700

M. Trim,
Building Research Energy Conservation Support Unit (BRECSU), Building Research Establishment, Bucknalls Lane, Garston, Watford, Herts, WD2 7JR, Great Britain.
Tel:0923 894040 Telex: 923220 Fax: 0923-664010

P.J.J. Jackman,
BSRIA, Old Bracknell Lane West, Bracknell, Berks, RG12 4AH, Great Britain.
Tel: 0344-426511 Telex: 848288

USA

***M. Sherman,**
Energy and Environment Division, Building 90, Room 3074, Lawrence Berkeley Laboratory, Berkeley, California 94720, USA.
Tel: 415/486-4022 Telex: 910-366-2037 Fax: 415 486 5172

R. Grot,
Building Thermal and Service Systems Division, Centre for Building Technology,National Bureau of Standards, Washington D.C. 20234, USA.
Tel: 301/975-6431

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

D. Harrje,
Centre for Energy and Environmental Studies, Princeton University, Princeton, New Jersey 08544, USA.
Tel: 609 258 5190
Telex: 499 1258 TIGER
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Head of Centre Martin W Liddament BA, PhD.

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