Air
Infiltration
Review

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Checking The Performance Of Ventilation Systems: The Swedish Approach

by Per Granqvist, The Swedish National Board of Housing, Building and Planning and Johnny Kronvall, Technergo AB

In recent years, poor indoor climate has increasingly been seen as the cause of health problems for building occupants. Today, there is good evidence in some areas why such problems arise. Unhealthy substances given off by various building materials, the existence of mould and general air pollution are the main causes. In general, the most important way to remedy the problem is improved ventilation. Poor upkeep and maintenance have led to a decline in the performance of existing ventilation systems.

Briefly this is why the Swedish Parliament and Government decided, in complete political unanimity, to introduce regulations on compulsory inspection of ventilation systems. The National Board of Housing, Building and Planning has issued the general guidelines about performance checks on ventilaation systems which are presented briefly in this article.

Why check ventilation?

For a good indoor climate

One basic condition for a good indoor climate is ventilation that works properly. Defects are often simple to remedy. Sometimes it is only a matter of changing a filter or a fan belt or cleaning a dirty ventilation unit. Good ventilation performance requires a properly run operation and maintenance organization which makes regular inspections.

For a good return of investments

Installations in modern buildings account for a large proportion of building costs. To ensure these investments are not wasted, adjustments must be carried out properly when the building is brought into use. These adjustments require regular follow-up inspections so that performance does not decline over time.

For lower operation and maintenance costs

Well-managed installations result in lower operation and maintenance costs. The life-span of equipment and components is lengthened and this also helps to keep total costs down. With well-managed installations it is furthermore possible to reduce the electricity needed for running the systems.

In this issue

The legal side of compulsory ventilation performance checks

The compulsory ventilation performance checks are based mainly on two Swedish law acts; the Swedish Planning and Building Act (PBA 1987:10) and the Swedish Work Environment Act (1977:1160). They both apply to a good indoor climate and the owner of a building is responsible for ensuring this.

Hence, it was possible to introduce compulsory ventilation performance checks and the owner of a building shall be responsible for ensuring that all checks are carried out, both before a ventilation system is brought into use for the first time as well as at repeated intervals during the building's lifetime. Checks are to be carried out by an inspector who has either received national authorization from the Swedish National Board of Housing, Building and Planning or has been approved by a municipality i.e. local authorization.

If the owner of a building does not follow the regulation about the compulsory ventilation performance checks or fails to remedy stated defects, the municipality can (according to PBA) order the owner to carry out required measures and, where necessary, link this to a fine.

Compulsory ventilation checks

Extent

For a ventilation system already in use before 1st January 1992, the first inspection shall be carried out before the end of 1993, 1994 or 1995, depending on the type of building and ventilation systems.

When inspecting a new installation, not only shall the current regulations be observed, but checks shall also be made that drawings and design documents have been followed, that the ventilation system is correctly adjusted and that it works in a satisfactory manner. If the designer has specified higher ventilation requirements than required by the regulations, then the inspection shall also check that these requirements are met. The inspector shall also check that the system does not include any contamination which can spread throughout the building and that instruction and operation manuals are readily accessible.

When inspecting an existing installation the inspector shall check that its performance and other aspects conform to the regulations that were in force when the system was brought into operation and that the system, in general, operates in the way intended. The existance of contamination as well as the availability of instruction and operating manuals shall be checked in the same way as for the inspection of new installations.

The inspection shall primarily involve the carrying out of total flow rate measurements in combination with random checks of representative dwellings or premises.

Exemptions

Performance checks shall be carried out in all buildings with the exception of

- detached and semi-detached dwellings with natural ventilation
- detached and semi-detached dwellings with only mechanical exhaust air ventilation
- buildings for agriculture, forestry or similar activities
- industrial buildings
- buildings which are for the Total Defence purposes and are secret.

Dates and intervals for regular inspections

Prescribed dates and intervals for regular inspections and approved authorization level of the inspector are shown in table 1.

Table 1

Buildings	Last date for first inspection of existing building	Inspection intervals	Inspector qualificat-ions class
1. Day-care centres, schools, health care centres etc.	31 Dec 1993	2 years	K
2. Blocks of flats and office buildings etc. Balanced ventila-tion.	31 Dec 1994	3 years	K
3. Blocks of flats and office buildings etc. Mechanical ex-haust ventilation.	31 Dec 1995	6 years	N

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. Please note that all submitted papers should use SI units.

4. Blocks of flats and office buildings etc. Natural ventilation.	31 Dec 1995	9 years	N
5. One and two-dwelling houses. Balanced ventilation.	31 Dec 1995	9 years	N

If the inspection identifies faults, these should be remedied within 6 months, so that a repeated inspection gives a satisfactory report. If a property ownner does not fulfil his/her responsibilities, the municipality can order the property owner to carry out the necessary measures.

The inspectors' qualifications

Authorization is issued for two different levels: authorization N is for simple installations and authorization K for more complicated installations.

Authorization N entitles the holder to check the ventilation systems in one- or two-dwelling houses as well as natural and mechanical ventilation systems in block of flats and offices etc.

Authorization K entitles the holder to check all types of ventilation systems.

General technical qualifications

Examination from (either of):

a) an institute of technology

b) engineering training at a former three and four-year technical college

c) present technical college four and five-year technical training

d) professional technical training at a university college or

e) other training which the National Board of Housing, Building and Planning regards as of equivalent value.

In all cases it is assumed that the training has been aquired as part of studies in appropriate technical subjects, such as building or installation technology.

Practical experience

N authorization: Professional work for at least three years in some of the following fields; design, production management, inspection or checking of ventilation systems except balanced systems in larger buildings.

K authorization: As above, but professional work for at least five years and inspection and checking of all kinds of systems (with or without heat recovery).

Supplementary training

If the applicant lacks professional experience of adjustment and/or inspection and checking, then the applicant shall undergo supplementary training in these fields.

Knowledge about administrative regulations

Knowledge about the Swedish administrative procedures concerning building permits and contacts with the authorities.

Inspection implementation

There are considerable variations in how installations and buildings are designed and constructed. Each ventilation performance check should therefore be adapted as far as possible to the individual building. However, the following points shall always be included in a ventilation performance check:

- Operation and maintenance instructions
- Air change
- Humidity
- Fans and air handling units
- Recirculated air
- Deposits in ventilation ductwork
- Radon
- User viewpoints

Reports

A report on the results of checking the performance of a ventilation system shall be drawn up and signed by the inspector. The report shall be sent to the property owner and the municipality.

Certificate

A special certificate will be issued after an inspection has been carried out and include the date of the inspection. The property owner shall place the certificate in a clearly visible position in the building.

Present status of the work

At the present time the Swedish National Board of Housing, Building and Planning is not able to present a nation-wide review on the results of the ventilation performance checkings carried out during 1993. A questionnaire will be sent out to all municipalities (287) in order to get back information on how the checkings have been performed in practise. The frequencies of passed / unpassed systems, number of exemptions (if any) and number of applicants who have been given local authorization by the municipality will be reported.

In spite of a strong resistance against this authoritarian control - initially - now almost all building owners admit that this really was necessary by no means less seen in the perspective of appr. 30 % of the Swedish population suffering from hypersensitivity in one form or another.

Operation and maintenance instructions are often found to be lacking. The ducts are in many cases very dirty, giving rise to strongly reduced flow rates and imbalance in the ventilation systems.

A more detailed report on the results of the ventilation performance checking will be presented later this year. Finally, it could be mentioned that there has been shown a particular interest in the Swedish performance checking from many other countries around the world . The problems of badly performing ventilation systems are not unique to Sweden...

References

Checking the performance of ventilation systems, General Guidelines 1992:3 (In English, to be published soon). The book could be ordered from The Swedish National Board of Housing, Building and Planning, P.O.Box 534, S-371 23 KARLSKRONA, Sweden.

ASHRAE Winter Meeting New Orleans, January 1994

Martin W Liddament

A considerable proportion of building energy use is often needed to heat or cool indoor air. From an energy aspect it is therefore desirable to minimise the amount of incoming air that needs to be treated. Unfortunately, this can impact on air quality and thus the subject of indoor air quality has become inextricably linked to ventilation energy use in buildings. Essentially, the quality of air is improved either by ventilation (which is energy intensive) or by controlling the sources of avoidable pollutant emissions. As a consequence, the subject of air quality attracts much interest and this was particularly evident at the ASHRAE Winter meeting held in New Orleans. Symposia, Seminars, Technical Committee and Standards meetings related to ventilation and air quality were all well attended.

ASHRAE Seminars

An increasing number of seminars are finding there way into the ASHRAE programme. Unfortunately, papers or proceedings of these seminars are not published, yet, much interesting material is often presented. The wide use of parallel sessions also inhibits the opportunity to follow all the relevant sessions. Of those attended, the following were of particular interest:

Outdoor Air

An essential prerequisite of good indoor air quality is that the outdoor air itself should be pollutant free. A seminar entitled "Complying with the clean air act amendments of 1990" concentrated on this particular issue. The Act applies to the United States and has been introduced to limit and reduce harmful pollutant emissions into the atmosphere. It addresses the following topics:

(i) Attainment and maintenance of ambient air quality Standards
(ii) Motor Sources
(iii) Hazardous air pollutants
(iv) Acid Deposition (from power utilities)
(v) Permits
(vi) Stratospheric Ozone Pollution

The Seminar specifically focused on issues (i), (iii) and (v). Attainment and Maintenance is directed at locations where major pollutants exceed specified concentration criteria. Included in this list are CFC's, oxides of nitrogen, ozone, lead and volatile organic compounds. The degree to which concentration is exceeded is categorised into five bands, varying from marginal to extreme. Target dates have been set for when the concentration criteria must be met; these range from between 1997 for the marginal band to 2010 for the extreme band. Control measures include emission caps, permits and other restrictions. Emissions from new sources are only permitted if they are offset by reducing emissions from existing sources by a greater amount, i.e. an 'offset' ratio of greater than one must be applied. Emission caps prevent a company from increasing the rate of pollutant emission as its business expands.

Indoor Air Quality

A seminar on indoor air risk assessment reviewed the difficulties often experienced in establishing the risk to health associated with the presence of contaminants in a building. Typically, health risk assessment is based on a linear extrapolation of data from a known risk condition. The presence of radon gas and volatile organic compounds (VOC's) were cited as good examples of pollutants which have unresolved and seemingly unresolvable health risks. This, it is argued, is because the predicted number of occupants likely to be seriously affected is minute in relation to the total size of population that develop cancers.

Odour

Odour can be particularly pervasive and uncomfortable. It is possible therefore, that a large amount of ventilation may be needed to dilute odours to an acceptable level. As a result, it is often odour criteria that may represent the dominant need for ventilation. While no solutions were offered on how odour may be controlled or minimised a seminar entitled "Odour and Mood", provided some interesting insights into the physiological and psychological influences of odour. Susan Knasko of the Monell Chemical Senses Center in Philadelphia described a range of measurement methods on building occupants aimed at linking odour to both mood and ability to carry out simple tasks. Her series of studies illustrated methods which may be used to evaluate the impact of pleasant and unpleasant odours and on congruent odours (i.e. those associated with the environment) and incongruent odours (i.e. odours which were out of place with the environment). These studies indicated that occupants were more likely to perceive or be aware of the presence of a pleasant odour if they were in a good mood and more likely to be aware of the presence of a bad odour if they were in a bad mood. It was also noted that certain odours appeared to have mood or health enhancing properties. Congruent odours were found to play a substantial role in decision making but only a minor role in relation to mood and state of health.

Schools

Problems associated with the ventilation of schools were dealt with by a seminar entitled 'Contaminant and Contaminant Control in Schools'. Currently ASHRAE Standards recommend a minimum ventilation rate of 8 l/s for each classroom occupant. The earlier 1981 Standard permitted a reduced rate of 2.5 l/s as an energy conservation measure. Upgrading such systems has proved to be expensive. Adequate ventilation, good maintenance and the source control of pollutants were cited as essential methods for improving the school environment.

There is a possibility that the ventilation of schools will come under closer scrutiny if a new ASHRAE Work Statement on school ventilation is accepted. This research proposal is aimed at exploring relationships between illness in schools and ventilation rate.

TECHNICAL and STANDARDS COMMITTEE MEETINGS

The development of ASHRAE Research Programmes and Standards forms a major part of ASHRAE Meetings. These programmes evolve through the work of Technical and Standards Committees. ASHRAE is currently looking for international representation on many of these groups. Committees interested in air flow and ventilation include:

Technical Committee 2.5 Air Flow Around Buildings

This Committee met to develop plans for a Symposium on the flow of contaminants into buildings from outside. It is also progressing Work Statements for ASHRAE funded research on screens around air conditioning cooling towers and on the siting of air inlets. Future plans for sponsored research include the application and evaluation of computational fluid dynamics (cfd) to predict air flow patterns and wind pressure distributions around urban buildings.

TC 4.3 Ventilation Requirements and Infiltration

ASHRAE Standard 62 on Minimum Ventilation for Adequate Indoor Air Quality is the responsibility of this committee. Other Standards it has developed include:

119 Air leakage performance for detached single family residential buildings.

136 A method for determining air change rates in detached dwellings.

This group has also initiated the preparation of a new standard covering the seasonal efficiency and steady state performance of residential air distribution systems. This will be primarily concerned with the duct leakage performance .

Other committees relevant to ventilation energy and the indoor environment include:

- TC 2.4	Particulate Air Contaminants/Removal Equipment.
- TC 4.2	Weather Information
- TC 4.7	Energy Calculations
- TC 4.9	Building Envelope Systems.
- TC 4.10	Indoor Environmental Modelling
- TC 5.l	Room Air Distribution
- TC 5.5	Air to Air Energy Recovery
- TC 5.6	Control of Fire & Smoke
- TC 5.8	Industrial Ventilation
- TC 6.7	Solar Energy Utilisation
- TC 7.5	Room Air Conditioners and Dehumidifiers
- TC 9.1	Large Building Air Conditioning Systems
- TC 9.2	Industrial Air Conditioning
- TC 9.6	Systems Energy Utilisation
- TC 9.8	Large Building Air Conditioning Applications

ASHRAE STANDARD 62 Minimum Ventilation for Acceptable Indoor Air Quality

This Standard which was last revised in 1989, has become widely accepted as a model Standard for use both within the United States and in other parts of the world. It is now undergoing a complete revision.

Proposed sections cover:
- Purpose
- Scope
- Definitions
- General Requirements
- Design Procedures for Commercial-Institutional Buildings
- Design Requirements for Residential Buildings
- Documentation of Design and Operational Guidelines
- Operating and Maintenance Procedures

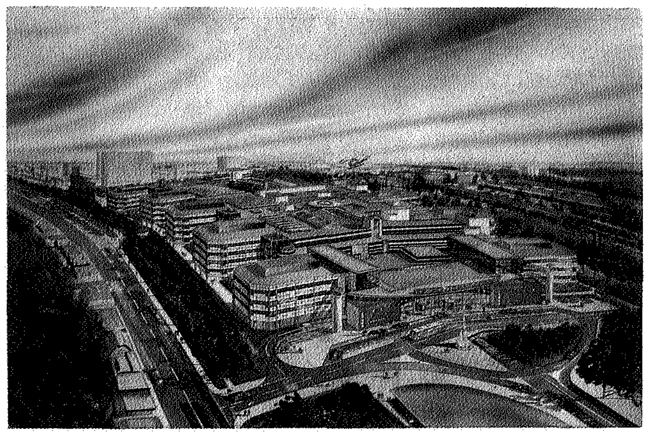
The purpose of this Standard is to:
- define the roles of and the requirements for ventilation, source management, and air cleaning in providing acceptable indoor air quality.
- specify methods for determining minimum ventilation rates.
- specify ventilation system design, operational, and maintenance requirements for various types of occupied spaces.

The first draft has now been prepared. This contains a substantial 'general' section covering the basic principles of ventilation. Sections covering commercial buildings, residential buildings and operating and maintenance procedures have also been drafted. Appendices have also been drafted to cover air quality criteria for the indoor environment, ventilation effectiveness, meeting the needs of transient occupancy and measurement methods.

TECHNICAL SESSIONS AND SYMPOSIA

Papers of technical sessions and symposia are published by ASHRAE. A technical paper presented by Don Colliver from the University of Kentucky described the development of the ASHRAE building component air leakage database as published in the 1993 Fundamentals. It is reported that the AIVC's bibliographic database - AIRBASE was used as an extensive source of information.

Air flow related symposia topics included atria performance and room air movement. Peter Simmons from RTG Van Heugten in the Netherlands described the performance of a nine interlinked atria hospital building. Combined thermal and ventilation modelling techniques were used for design and evaluation. Computed results compared favourably with operational performance.



Peter Neilsen from Aalborg University in Denmark described the results of measurements of stratified (displacement) ventilation air flow in a room. Flow could be regarded as two dimensional if the room is ventilated by a number of diffusers placed close to each other on one side of the wall. It was shown that a single semi-empirical equation could be used to describe the flow velocity in the occupied zone.

In a series of three papers, Richard Kelso and Professor Baker from the University of Tennessee and Paul Williams from Oak Ridge National Laboratory described the development and testing of a three-dimensional computational fluid dynamics model. This was found to perform well.

For further details of ASHRAE Meetings or for additional information on published papers, please contact Martin Liddament at the AIVC (Address at back of this newsletter.)

Recent Research at the University of Essen, Germany

Technical Visit Report by Malcolm Orme, AIVC Scientist

Research currently being conducted at the Institut für Angewandte Thermodynamik und Klimatechnik, (Applied Thermodynamics and Air-Conditioning), University of Essen can be grouped into the following areas:
- heat pumps, including the investigation of compression and absorption cycles,
- recovery of waste heat with thermal power processes,
- development and testing of air-conditioning plant,
- the behaviour of air-conditioning plant in-situ with particular emphasis on air flow in confined areas,
- the study of alternative refrigerants, and

- the exploitation of solar energy.

Direction Sensing Thermal Anemometry

In addition to the above areas, the calibration and uses of thermal anemometers are being studied. These can be used for the measurement of indoor air flows. For instance, a thermal anemometer device has been developed over several years which allows the precise magnitude and direction of the velocity of air movements to be determined. This consists of twelve negative temperature coefficient (NTC) resistors placed at points on the surface of a plastic sphere, forming a globe-sensor. Calibration curves must first of all be deduced for the device, which relate the angle of incidence of an air stream to its velocity for all of the resistors. By comparing field measurements from the globe-sensor with the calibration curves, the magnitude and direction of the air velocity can be found. The globe-sensor is described in more detail in #5262 and the locations of the resistors are shown in Figure 1. Whilst it is convenient to use, it can be easily transported for on-site measurements of air flows in buildings. It is less expensive than the Laser Doppler technique and is more accurate than vane anemometry at low air velocities.

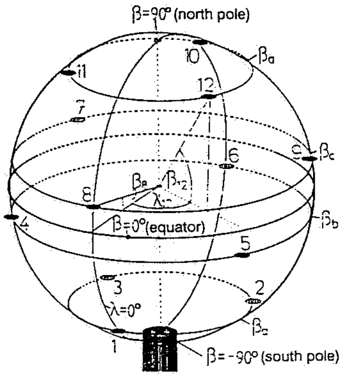


Figure 1 Spatial Distribution of Twelve NTC resistors on Globe-Sensor. (Source: #5262)

Solar Energy Storage

In the past the use of available solar energy has been restricted by the lack of an efficient method for storing any surplus energy produced. In many temperate climates, photovoltaic cells are unable to produce a guaranteed energy supply when it is most needed. A solar energy research project being carried out at Essen is trying to rectify this problem by using a reversible photochemical reaction to store energy during months of high direct solar radiation for use at other times. Using the process under development, about 14% of the available solar energy is utilised (at the 500 nm wavelength). More specifically, high energy visible light is used to convert Norbornadiene (Bicyclo[2,2,1]hepta 2,5 diene) into an isomer, Quadricyclan (Tetracyclo[3,3,0,0,0]heptan). The stored energy is released in the form of heat by the catalysed reverse reaction which converts Quadricylan to Norbornadiene. The use of various cyano-, methyl and phenyl substituted Quadricyclans has also been considered as the storage medium. The usable energy stored in 4 m3 of substituted Quadricyclan is estimated to be of the order of between 2x109 J and 4x109 J (at storage densities of 0.5 kJ.g-1 and 1.0 kJ.g-1 respectively). The stored energy can be exploited, for example, by using either absorption heat pump or absorption cooling equipment.

Retrofitting of Ventilation Systems

A client provided funding for the department at Essen, so that a new ventilation system could be designed and a mock-up test section constructed, in order to ensure occupant comfort in an existing office building. Part of the considered problem was to eliminate draughts in the vicinity of a table placed in the test room. The new design was tested by checking that the air velocities around the table were low enough when the air temperature was stabilised to either 22 oC (winter level) or 26 oC (summer level). (At higher temperatures the effect of draught on thermal comfort is less noticeable.) Thermocouples, placed in the vicinity of the table, were used to achieve the correct temperature. The velocities were found with four thermal anemometers, one placed at each location listed below:

- just above floor level,
- the height of the head of a seated occupant,
- the height of the head of a standing occupant, and
- just below ceiling level.

The presence of a person in the office was simulated with a heated mannequin (emitting heat at the rate of 100 Watts). A sealed enclosure surrounding the office windows enabled simulated external air temperatures to be adjusted. Solar heating effects were incorporated by increasing the internal heating load by an equivalent calculated quantity.

The tested design requires that in the actual building, a primary air supply is pre-heated to about 17 oC and (de)humidified to a suitable level. This occurs outside the office, at a central location elsewhere in the building. Window induction units either heat or cool the primary air supply in order to attain the desired room temperature and use forced convection to circulate the air around the room to the exhaust outlet.

Combined Ventilation and Floor-Heating

A combined ventilation and floor-heating system is being developed at Essen which has lower thermal inertia than conventional floor-heating alone. A cavity is created in the floor structure by using concrete spacing 'cones'. Water heating pipes are embedded in concrete above this cavity. The cavity has outlets into the room above, near to the external wall of the building. Supply air is pre-heated to about

10 oC (by heat recovery from exhaust air). The supply air passes through the cavity underneath the heating pipes and is thus heated to approximately 25 oC. The water pipes also heat the room directly by the conduction of heat through the floor. The arrangement is shown in Figure 2. This method removes the need for strongly heated supply air, therefore ensuring hygienic conditions are more easily maintained. Additionally it provides air needed for ventilation and gives more accurate control (with a more uniform temperature distribution) than many other systems. More information can be found in #7021.

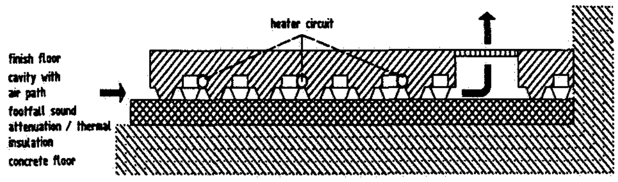


Figure 2 Combined Ventilation and Floor-Heating System. (Source: #7021)

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International Energy Agency
Air Infiltration and Ventilation Centre

15th AIVC Conference
The Role of Ventilation

The Palace Hotel, Buxton, Great Britain
Tuesday 27th - Friday 30th September 1994

Preliminary Notice

Ventilation is an essential mechanism for the control of pollutant concentration in buildings. However, this is an energy intensive process which, as pollutant sources increase, accounts for an ever greater proportion of a building's space heating or cooling need. Sometimes ventilation may be applied when source control may be more appropriate; at other times a change in ventilation strategy rather than an increase in ventilation rate may secure improved indoor air quality. The purpose of the AIVC's 15th Annual Conference is to reflect on the role of ventilation in providing an energy efficient, optimum indoor environment. It is aimed at researchers and at building services specialists who wish both to learn about and implement new design concepts.

Topics include:
- Ventilation for indoor air quality control
- Effective ventilation strategies
- Minimum ventilation rates
- Alternative IAQ control methods
- Energy and global impact of ventilation - CO_2 emissions
- Coping with external pollutants
- Case studies
- Building design for optimum ventilation
- Calculation, measurement and design tools

Further details from:

Mrs Rhona Vickers
Air Infiltration and Ventilation Centre
Sovereign Court
Sir William Lyons Road
Coventry CV4 7EZ
Great Britain

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

Natural Ventilation Of Parking Garages

Dimensioning of Ventilation Units with the Assistance of Air Flow Models

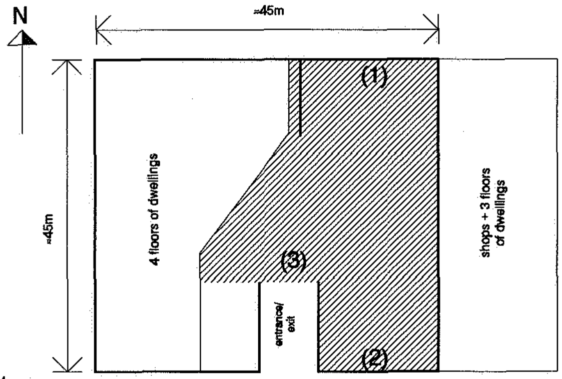
by W. Kornaat and A. D. Lemaire
TNO Building and Construction Research, Delft, the Netherlands

Introduction

Parking garages require ventilation because the exhaust fumes produced by the vehicles have to be discharged. This can be achieved with a mechanical or a natural ventilation system. A natural ventilation system has several important advantages compared with a mechanical system. As a rule natural ventilation systems are simpler, cheaper and have fewer breakdowns. Furthermore a natural system requires less maintenance and uses no energy (for air transfer). For the dimensioning of the necessary ventilation units in a parking garage, the calculating regulations (for The Netherlands) are given in NPR 2443 "parkeergarages" [1]. Recently the department of indoor environment, building physics and systems of TNO Building and Construction Research has carried out further investigations regarding naturally ventilated parking garages. Using a multi cell ventilation model [2] research has been carried out to check if enough natural ventilation can be maintained, while the regulations according to NPR 2443 are not precisely taken into account. In this article one of these investigations [3] will be discussed. This concerns an investigation by which also the airflow (concentration distribution) is investigated with a so called CFD- Model [4], which stands for Computational Fluid Dynamics.

The parking garage

The investigation relates to a parking garage in a housing and shopping complex. An ariel view of this complex is given in figure 1. It concerns a relatively small parking garage with 49 parking spaces intended for the inhabitants of the complex. On the west side, above the parking garage, an apartment block is situated, and on the east side the parking garage borders on the shops. In the walls of the parking garage no ventilation provisions can be installed, because these walls are under ground level or border on other areas (e.g. the shops on the west side). Natural ventilation provisions can only be installed in the roof of the parking garage (see shaded area in figure 1). The part directly next to the entrance/exit is not shaded, because the storage block is situated here and therefore no provisions can be installed. From the above mentioned it seems that due to the possible positioning of the ventilation provisions, a good through ventilation of the west area of the parking garage (under the apartment block) is questionable. In particular this applies to the south/west area, where the storage block hinders a direct air distribution via the entrance/exit. The investigation with the CFD-model is to gain insight into the through ventilation of these areas.



Notes:

- *- the contour of the parking garage is indicated with thick lines;*
- *- the shaded area gives the possible positioning of the ventilation provisions.*
- *- 1 to 3 are the ventilation provisions modelled in the VenCon ventilation model*

Figure 1: Ariel view of the complex

Required ventilation

By ventilating it is necessary, as previously mentioned, that the produced exhaust fumes are discharged properly. As principle pollutant the carbon monoxide (CO) in the exhaust fumes is hereby upheld. The carbon monoxide production is dependent on the following :

- - the CO-emission per vehicle
- - the traffic load, for example expressed by the amount of in or outgoing vehicles per hour.
- - the driving time of a vehicle in the parking garage, especially the time that the vehicle is present with the engine running.

For the CO-emission per vehicle is stated 0,17*10-3 m^3/s in NPR 2443[1]. Note that this NPR dates back to 1978. During the last few years due to the increased environmental requirements, the exhaust fumes of cars have become considerably "cleaner". The CO- emission in cars nowadays is therefore probably considerably lower than the rates mentioned in NPR 2443. By sustaining the CO-emission according to NPR a certain security margin is built in nevertheless.

Guidelines for the traffic load are given in the literature [5]. Distinction is hereby made between a parking garage for an office complex and for the shopping public. For an office complex as peak traffic load is given the situation that one hour before (after) working hours all vehicles arrive (depart). For the shopping public a wider utilisation is taken into consideration. It is assumed that the use of the parking garage in this housing complex is the same as in an office complex. As peak load therefore the assumption is made that in one hour all 49 vehicles depart (arrive). The driving time is dependent on the average driving distance, the driving speed, the time necessary for parking and a possible waiting time by leaving the parking garage. In this case the driving time is about 60 seconds, considering an average driving speed of 5 kilometers/hour.

By calculations on the basis of the above points, it has been found that for a situation with a peak in the traffic load, the CO-production is 1,39* 10-4 m^3/s.

The ventilation needs to be sufficient to keep CO-concentrations smaller or similar to the maximum accepted concentration (MAC-value) even by a peak in the traffic load. Taking into consideration complete mixing, the required ventilation can be determined from the quotient of:

- - the CO production
- - the MAC value of CO in the parking garage minus the CO-concentration in the entering ventilation air.

The exposure of the users in the parking garage can be regarded as short (not more than 15 minutes) and incidental. The MAC value for CO is then 150 ppm. For a city centre literature [6] shows that CO-concentrations in the outdoor air can lay in the neighbourhood of a scale of 20 ppm.

Calculations based on those above mentioned now show that the ventilation, for a situation with peak load, must be approximately 1 m^3/s.

Dimensioning ventilation provisions

As criteria with naturally ventilated parking garages it is frequently considered that the necessary ventilation (in this case 1 m3/s) needs to be maintained by wind speeds greater or equal to 1 m/s. Lower wind speeds only arise 5% of the time. The chance that a situation whereby the ventilation level is lower than that required, occurs in combination with a peak in the traffic load, is then limited. By the investigation with the multi cell ventilation model is, in relation with the through ventilation in north/south direction of the parking garage, chosen to place ventilation provisions in the roof of the garage at the positions 1 and 2 (see figure 1). In the model the entrance/exit (3) is also modelled as ventilation opening, because this cannot be closed and therefore is always fully open. The so called wind pressure coefficients, with which the wind pressure on the ventilation provisions is simulated, are derived from literature [8],[9]. The model investigation shows that the aforementioned criteria are met in case the net opening of the provisions on position 1 and 2 are respectively 8 and 2 m^2. For the net opening of the entrance/exit 10 m^2 is hereby assumed. The occurring ventilation with these provisions is given as a function of the wind speed for the 4 major wind directions in figure 2.

Figure 2 shows furthermore that the ventilation increases somewhat more than linear with the wind speed. This is also a vital advantage of a natural system in relation to a mechanical system. By the dimensioning for a situation with a low wind speed, in this case 1 m/s, the ventilation shall for the largest part of the time be significantly higher than required. In this parking garage this leads to a ventilation 5 or more times higher than required by the average occurring windspeed of about 5 m/s. Hereby the average exposure of users to pollutants and also the possible inconvenience decrease in a strong way.

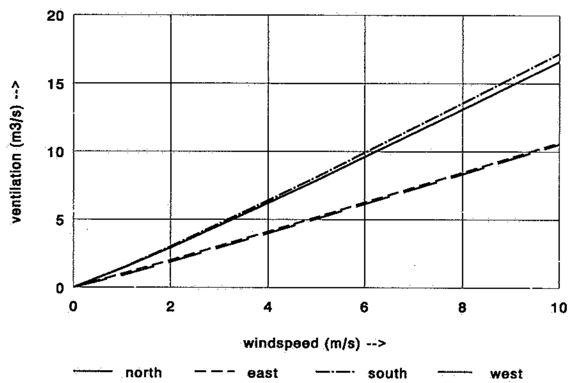
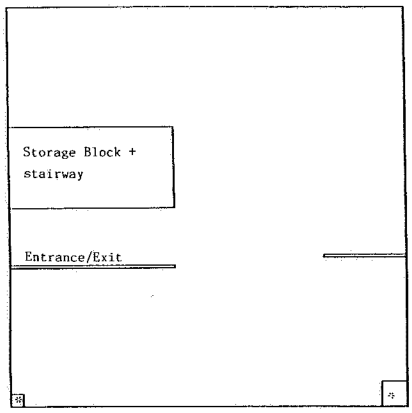


Figure 2: Ventilation as a function of the wind speed for the 4 major wind directions.

Air flow pattern and concentration distribution

With a CFD-model the air flow pattern can be calculated in a room. In this case the in and outlet flow capacity via (the air speed in) the ventilation openings of the parking garage, as were calculated with the multi cell ventilation model, are used as input. In the CFD-model an equal or unequal source distribution over the floor can be simulated. In this case as source is simulated the CO-production of the cars. The dispersion and concentration distribution in the parking garage as a result of the air flow pattern can then be determined.

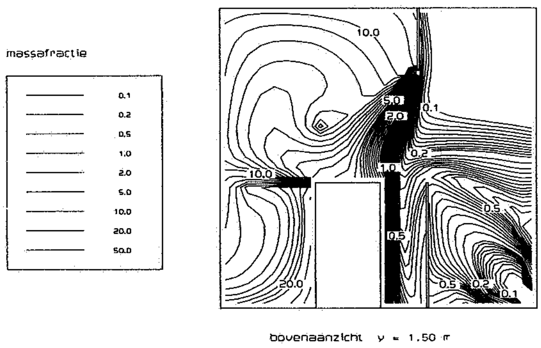
A floor plan of the model of the parking garage used by the CFD-calculations is shown in figure 3. Alongside the entrance/exit the storage block is modelled as obstacles.



** ventilation provisions in the parking garage roof.*

Figure 3: A floor plan of the model of the parking garage used by the CFD-calculations.

The through ventilation and concentration distribution is investigated for the situation with extra provisions in the roofing area (see ventilation investigation mentioned earlier). For the most unfavourable situation (west wind and a wind speed of 1 m/s) this concentration distribution is given in figure 4. During these circumstances the outlet of polluted air takes place via the entrance/exit, whereas the air inlet takes place via the 2 roof grilles. It is noted that the given concentration distribution is regulated on the concentration in the outlet flow (concentration in outlet flow is considered 1). The total ventilation is under considered weather conditions approximately the same as the required ventilation (see figure 2). The concentration in the outlet flow is therefore approximately the MAC-value, while the local occurring concentrations correspond with the values according to figure 4 multiplied with the MAC-value. Note that a figure like figure 4 is usually printed in colour and is then easier to understand.



Note: the contour lines, situated between the contour lines with labelled values, increase with the differences in these values divided by 10.

Figure 4: Concentration distribution at a height of 1,5 m (in the breathing zone) by westerly wind and a wind speed of 1 m/s

From figure 4 it is clear that the through ventilation of the westerly half of the parking garage is inadequate. This applies namely to the south/west corner, where the concentration levels vary from 10 to 20 times the MAC-value. As a result of the inadequate internal mixing in the parking garage, the ventilation should actually be increased by a factor of 10 to 20 for maintaining acceptable CO-concentrations. This however leads to an unrealistically high ventilation level. Another possibility is to improve the internal mixing by applying "a mixing" fan. This possibility has been investigated with the CFD-model. Hereby the following two options are considered, namely:

a) application of a "mixing" fan, that transfers an air flow of 1 m^3/s along the west wall from south to north.

b) application of a "mixing" fan, that transfers an air flow of 0,5 m^3/s from the easterly half of the parking garage to the westerly half.

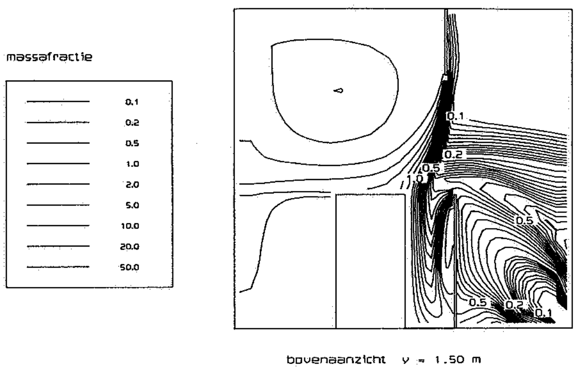
The calculated concentration distributions of these options are given in respectively the figures 5 and 6. From this it is evident that with both options the CO-concentration are reduced and remain limited to a maximum of approximately 1.5 times the MAC-value.

The transfer of the air from the easterly to the westerly half is the most effective. This is shown by the fact that hereby a smaller air flow rate is sufficient. The reason herefor is that actually air of the "clean" (with good through ventilation) half of the parking garage is transferred to the "more polluted" half.

It is recommended to use this "mixing" fan in practice on the basis of the occurring CO- concentrations. The switch on time of the fan will then remain limited to the situations with high traffic loads in combination with low wind speeds. It is expected that in practice the mixing will be better than calculated with the CFD-model. Therefore the switch on time of the fan shall likewise be smaller. This is due to the fact that by the model calculations a few aspects have not been taken into consideration, such as:

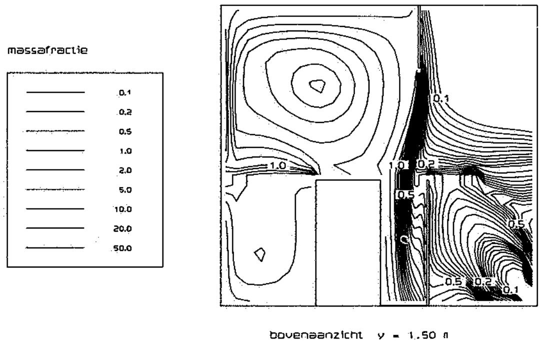
- local differences in the indoor temperature and surface temperatures. Orientating calculations with the CFD-model have demonstrated that a very strong internal air turbulence (mixing) already occurs, if the surface temperature of the west wall deviates 2 Deg. C from the air temperature. The CO-concentrations are hereby reduced from 10 to 20 times the MAC-value (see previously mentioned) to 5 or 7 times the MAC-value.
- the mixing due to the driving of the cars.
- the fact that the exhaust fumes are warmer than the air.
- the possible heat emission by the engines.

By not taking these aspects into consideration during the design, a certain safety margin is built in. If the design has to be optimised further, then it is desirable that additional research is conducted to a few of the aforementioned aspects.



Note: the contour lines, situated between the contour lines with labelled values, increase with the differences in these values divided by 10.

Figure 5: Concentration distribution at a height of 1,5m (in the breathing zone) by:
- westerly wind and a wind speed of 1 m/s
- a "mixing" air flow of 1 m^3/s along the west wall from south to north.



Note: the contour lines, situated between the contour lines with labelled values, increase with the differences in these values divided by 10.

Figure 6: Concentration distribution at a height of 1,5m (in the breathing zone) by:
- westerly wind and a wind speed of 1 m/s
- a "mixing" air flow of 0,5 m^3/s from the easterly to the westerly half.

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AIVC Survey of Research 1994

Late contributions to the Survey are still welcome. We take this opportunity to thank those researchers who have taken the time to complete the questionnaire for their help. This information will be of great value to others in the field when published. Please send your completed forms to Mark Limb, AIVC Scientist at the address on the back page of this newsletter. The survey will be published as an AIVC Technical Note later in the year.

Natural Ventilation Literature Review

A literature review on the subject of all aspects of natural ventilation in buildings will soon be available from the AIVC. It includes an analysis of relevant papers and other current literature from the AIVC's database, AIRBASE and other wide ranging sources.

Implementation and Assessment of a Low Reynolds Number K-ε Turbulence Model for Natural Convection Flow

by Samira Kherrouf and Philippe Buchmann, both PhD students at the Centre Scientifique et Technique du Bâtiment, Marne-la-Vallée, France

Introduction

The purpose of this study is to test the Launder-Sharma low Reynolds number k-ε model [1-2]. This model is intended to improve the forecasting of aerothermal behaviour in air conditioned rooms.

The model is based on the high Reynolds number k-ε model of the Phoenics code. The latter was chosen because it provides a sufficiently accurate representation of the physical phenomena and it appears to be relatively easy to use, given the interest it has encountered in the industry. However, the high Reynolds number k-ε model is only suitable for certain types of flow [3]. The limits of this model will be pointed out and the suggested improvements are validated in the case of a differentially heated cavity [4-6].

The high Reynolds number k-ε model is used for the square cavity, and the results are compared to those of other authors. The low Reynolds number k-ε model is compared to the previous model and its improvements are shown.

The improvements obtained with this model are validated by a comparison with reference results from direct simulations.

Mathematical Expression

We considered two differentially heated cavities with different aspect ratios: a square cavity and a rectangular cavity with an aspect ratio of 4. The floor and the ceiling are adiabatic and the vertical walls have stipulated temperatures. The Rayleigh number of the square cavity is 5E10 and that of the rectangular is set equal to 1E10. Several computation hypotheses were used. The fluid is incompressible and corresponds to the Boussinesq approximation (small temperature variations). The computations are two-dimensional.

The equations describing the turbulent flows are obtained from the Reynolds breakdown of the physical flow values and the temporal mean of the instantaneous Navier-Stokes equations.

$$\frac{\partial u_i}{\partial t} + u_j \frac{\partial u_i}{\partial x_j} = -\frac{1}{\rho}\frac{\partial p}{\partial x_i} + \frac{\partial}{\partial x_j}\left[(\nu + \nu_t)\frac{\partial u_i}{\partial x_j}\right] + g\beta\delta_{i2}(T - T_{ref})$$

$$\frac{\partial T}{\partial t} + u_j \frac{\partial T}{\partial x_j} = \frac{\partial}{\partial x_j}\left[\left(\nu + \frac{\nu_t}{\sigma_t}\right)\frac{\partial T}{\partial x_j}\right]$$

The equations are closed by a first order turbulence model. Two additional equations are solved. One determines the turbulent kinetic energy, the other the rate at which that energy is dissipated.

$$\frac{\partial k}{\partial t} + u_i \cdot \frac{\partial k}{\partial x_i} = \frac{\partial}{\partial x_i}\left[\left(\upsilon + \frac{\upsilon_t}{\sigma_k}\right)\frac{\partial k}{\partial x_i}\right] + G + P - \varepsilon - D$$

$$\frac{\partial \varepsilon}{\partial t} + u_i \cdot \frac{\partial \varepsilon}{\partial x_i} = \frac{\partial}{\partial x_i}\left[\left(\upsilon + \frac{\upsilon_T}{\sigma_\varepsilon}\right)\frac{\partial \varepsilon}{\partial x_i}\right] + C_1 \cdot \frac{\varepsilon}{k} \cdot (P + C_3 \cdot G) - C_2 \cdot f_2 \cdot \frac{\varepsilon^2}{k} - E$$

wherein

$$P = \upsilon_t \cdot \left[\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right]\frac{\partial u_i}{\partial x_j}$$

$$D = 2 \cdot \upsilon \cdot \frac{\partial\sqrt{k}}{\partial x_i} \cdot \frac{\partial\sqrt{k}}{\partial x_i}$$

$$E = 2 \cdot \upsilon \cdot \upsilon_t \cdot \left\{\frac{\partial^2 u_i}{\partial x_j^2} \cdot \frac{\partial^2 u_i}{\partial x_j^2}\right\} \cdot (1 - \delta_{ij})$$

$$G = -\beta \cdot g_i \cdot \frac{\upsilon_t}{\sigma_t} \cdot \frac{\partial T}{\partial x_i}$$

$$\upsilon_t = c_\mu \cdot f_\mu \cdot \frac{k^2}{\varepsilon}$$

$$R_t = \frac{k^2}{\upsilon . \varepsilon}$$

The constants and damping functions are listed in the following table:

MODELS	C_μ	C_1	C_2	C_3	σ_k	σ_ε	σ_t	f_μ	f_2
Initial	0.09	1.44	1.92	1.	1.	1.33	1.	1.	1.
Low Reynolds	0.09	1.44	1.92	1.	1.	1.33	1.	$\exp\left[\frac{-3.4}{\left(1+\frac{R_t}{50}\right)^2}\right]$	$1 - 0.3 \cdot \exp[-R_t^2]$

The boundary conditions for the turbulence variables depend on the model used:

i) for the high Reynolds number k-ε model: logarithmic wall law.

ii) for the low Reynolds number k-ε model:

$$\frac{\delta\varepsilon}{\delta n} = 0 \; , \; k = 0$$

Numerical Procedure

The spatial derivatives of the equations are discretized according to the finite-volume method and a staggered grid is used to compute velocities. The scheme used for the discretization of the transport equations is a hybrid scheme. The temporal scheme is of the implicit type.

The SIMPLEST algorithm used for computations is derived from the SIMPLE algorithm [7]. Pressure corrections were made in the same way. The difference is that the convection term of the transport equations is rejected to the source term, and the convective terms are solved point-by-point (Jacobi) while the diffusion terms are solved line-by-line (Gauss Seidel). The pressure is solved simultaneously for the entire domain. The mesh used is not uniform; it is indicated by the following expression [8-9]:

$$x_i = x_{max}\left\{-0.5\tanh\left[\alpha\left(2\frac{m}{n}-1\right)\right]/\tanh(-\alpha)+0.5\right\}$$

wherein the expansion coefficient α is equal to 3.5, x_i indicates the position of node i, n the number of nodes and m the number of the node.

Simulations were performed for different meshes (70x70, 100x100) and for different aspect ratios of the cavity (1, 4, 5). The results are given only for the 100x100 mesh.

The calculations were made on an HP9000/720 (Mflop) RISC workstation.

Results

The results obtained with the high Reynolds number k-ε model approach those of numerous authors [10], in particular for the mean values. But previous studies have shown several shortcomings of this k-ε model, which has led us to use a low-Reynolds number k-ε model [1].

The differences between these two models are clearly visible in the case of square cavity (Figs 1 to 8), and are explained by an overestimation of the turbulence (Figs 6 to 7).

FIGURE 1 Standard case; vertical velocity at y=H/2

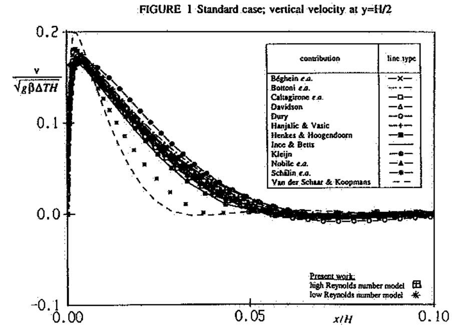


FIGURE 2 Standard case; horizontal velocity at x=H/2

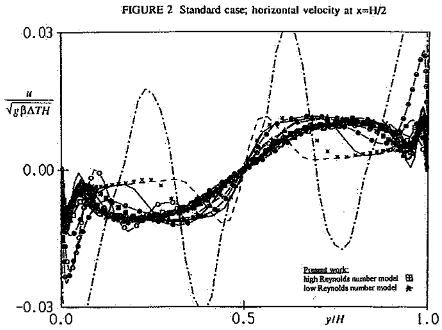


FIGURE 3 Standard case; horizontal velocity at x=H/2 (detail)

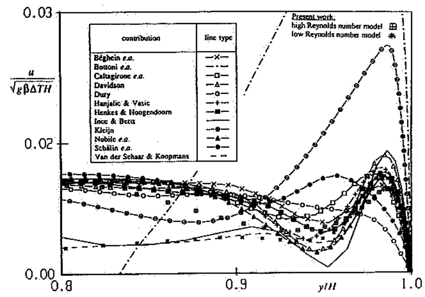


FIGURE 4 Standard case; temperature at y=H/2

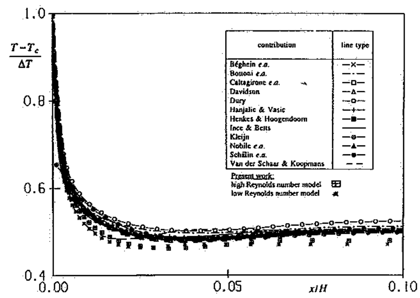


FIGURE 5 Standard case; temperature at x=H/2

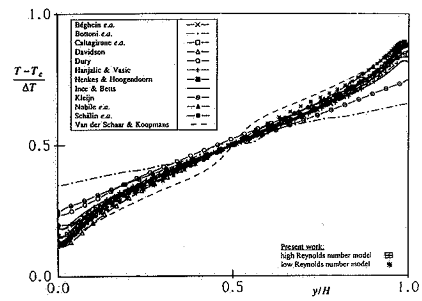


FIGURE 6 Standard case; turbulent viscosity at y=H/2

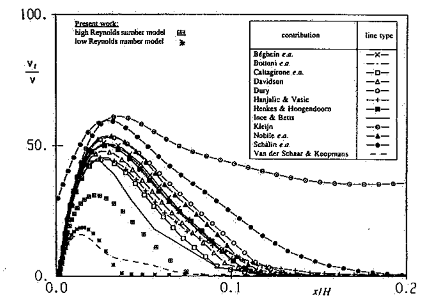


FIGURE 7 Standard case; turbulent kinetic energy at y=H/2

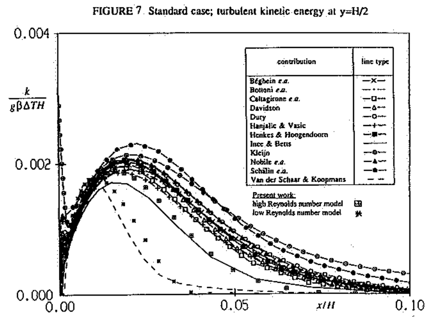
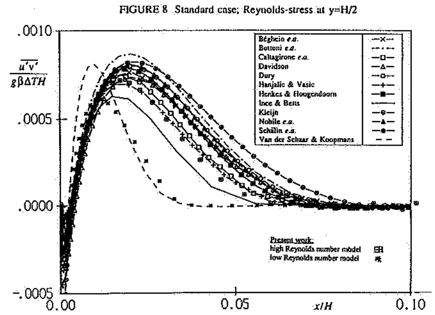


FIGURE 8 Standard case; Reynolds-stress at y=H/2



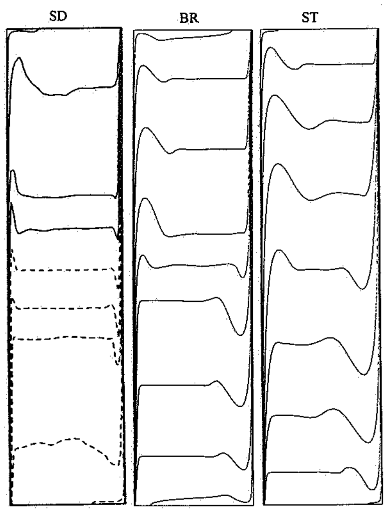
Figures 1-8

On the one hand, it appears that the heat transfers are overestimated by the high Reynolds number model, Nu_m-205, instead of Nu_m=158 for the other model. Simulations were made for different Rayleigh numbers to deduce a correlation between the Nusselt and Rayleigh numbers. The result is $Nu_m=0,0166.\ Ra^{1/2,7}$.

In addition, the mean dynamic distributions are very different (Figs 1 to 3). Conversely, the mean temperature distributions are not very much affected by the improvements made in the turbulence modelling. The stratification obtained with the low Reynolds number model is better, even though it is not very different. (Fig 7).

The direct simulation [11] used as reference makes it possible to estimate the precision of the low Reynolds number k-ε turbulence model. The latter produces better results than the high Reynolds number model for an identical mesh. The stratification is in fact more pronounced in the center of the cavity (Fig 9).

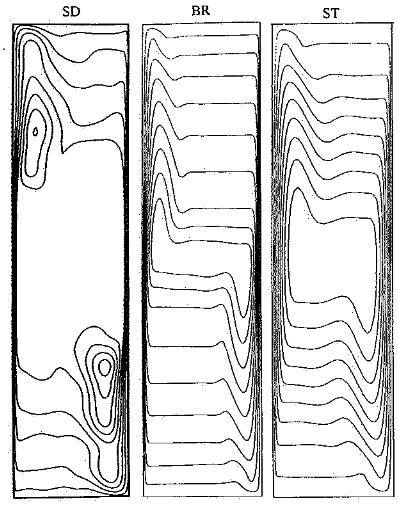
The results concerning turbulence approach those obtained by direct simulation. The overestimation of the turbulence in these calm zones disappears. One can in fact see that the extent of the high-turbulence regions is reduced and that the maximum turbulence moves towards the top of the hot wall and the bottom of the cold wall. This corresponds to the transition zone between the laminar and turbulent regimes.



SD: Direct simulations
BR: Low Reynolds number k-ε model
ST: High Reynolds number k-ε model

Figure 9: Isotherms

The boundary layers are modeled more accurately. They become narrower and the maximum velocities increase (Fig 11). The result is a compression of the flow lines in the near-wall area (Fig 10). This result is predictable since the flow regime is turbulent.



SD: Direct simulations
BR: Low Reynolds number k-ε model
ST: High Reynolds number k-ε model

Figure 10: Streamlines

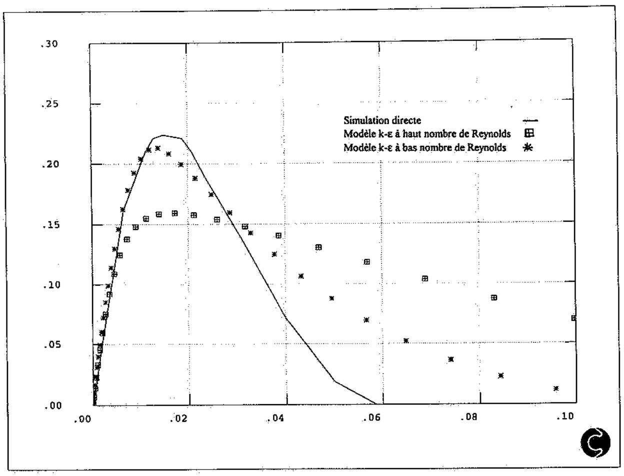


Figure 11: Mean velocities profiles at mid height of the cavity.

It can also be noted that the maximum dissipation rate obtained by our high Reynolds number k-ε model is very high in comparison to the other models. In view of the results for the turbulent kinetic energy and the turbulent viscosity, which show no anomalies, it can be assumed that this is in fact a "singularity" along the walls.

On the other hand, the recirculations observed in direct simulation do not appear, irrespective of the model or the mesh considered. This result may be linked to the position of the turbulence transition zone. For the results of the k-ε model, the latter is located lower on the hot wall and higher on the cold wall, which does not permit the development of recirculations.

The overestimation of the heat transfers is confirmed by the results obtained from direct simulation (Table below).

Turbulence models	NU_m
High-Reynolds-number k-ε model	133
XIN [10] : High-Reynolds-number k-ε model	131
Low-Reynolds-number k-ε model	105
XIN [10] : direct simulation	102

Table: Nusselt numbers obtained for different models for a Rayleigh number equal to 1.E10

For the meshes used, the results are only slightly different. But when a higher Rayleigh number is used, an asymmetry of the flow in the square cavity appears, which may be attributable to the fact that the mesh used is not sufficiently fine.
The results for the mean temperature distributions could be improved further by using the generalized gradient diffusion hypothesis (GGDH) as described by Daly and Harlow [12].

Conclusion

The low Reynolds number k-ε model considerably improves the results, particularly for the heat transfer levels largely overestimated by the high Reynolds number k-ε model, which is explained by an overestimation of the turbulence.
This model will be used for mixed convection air flow situations as it occurs with air conditioning systems.

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Perceiving Air Quality

By Nigel A Oseland MSc, UK Building Research Establishment

Summary

This paper is an abridged version of a recent BRE occasional paper.

The new units of perceived air quality, the olf and the decipol, are introduced. Research using these units has been used to argue that current recommended ventilation rates are inadequate for comfort.

The derivation of the units is questioned and it is proposed that their application be delayed until the methodology has been fully validated.

Perceiving Air Quality

Modern ventilation standards assume that man is the dominating polluter of non-industrial buildings and therefore ventilation rates are specified per occupant, often estimated by CO_2 levels. However, in reality, there are many sources of indoor pollution, including building materials, furnishings, equipment, and ventilation systems. Ole Fanger and colleagues have therefore developed a procedure in which subjective ratings of odour (and irritation) are used to quantify the air pollution in buildings. European "guidelines" recommend that ventilation rates in buildings are determined using this method. Although this proposal has obvious attractions, it has not yet been fully evaluated nor the developmental research fully explained. The limitations of the application and precision of the method are described elsewhere, but several fundamental queries concerning its derivation are described below.

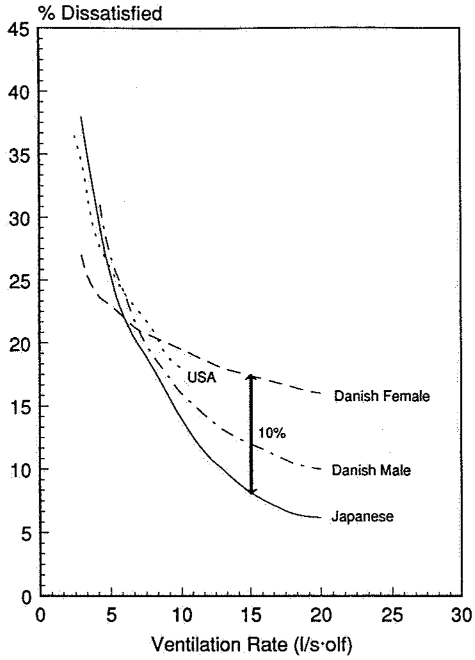
Trained panels are used to rate the air quality directly in decipols, a new unit of perceived air quality. One decipol is defined as *the pollution caused by one standard person (one olf) ventilated by 10 l/s of unpolluted air.* A standard person is a sedentary adult in thermal comfort who works in an office, or similar non-industrial work place, and bathes on average 0.7 times per day. The associated unit of pollutant source strength, the olf, is defined as *the emission rate of air pollutants (bioeffluents) from a standard person.*

So, the pollution source strength of various building materials, furnishings and equipment is quantified in units of body odour. However, as body odour varies and is difficult to store, a more stable reference to the olf is needed in practice. Thus, the panels are trained to make decipol ratings by "calibrating" their responses with acetone concentrations of known decipol value. They then rate the acceptability of the odour (and sensory irritation) of a building by comparing it to the acetone. At first glance this method appears fairly straight forward, but many aspects of it are quite puzzling.

The acetone quantities were initially calibrated in decipol using a *naive* panel, as there were no *trained* panels to rate the acetone. Naive subjects rated the acceptability of the air quality in an auditorium with varying numbers of occupants (olfs) at differing air supply rates (l/s). The relationship between the percentage dissatisfied (PD) and ventilation rate (l/s olf) was computed. Thus, the PD scores of the acetone were converted to decipol values. The number of olfs emitted from the building materials and furnishings in the auditorium could not be measured until the new units had been derived (a "chicken and egg" situation). So, if the olf load of the building was unknown then the total number of olfs (from the building and occupants combined) and the minimum olf level were also unknown, making it rather difficult to establish with confidence any relationship between olfs and PD.

By definition the relationship between the decipol and olf is linear, ie 1 decipol is the pollution perceived from 1 olf at 10 l/s (or 2 olf at 10l/s) and 2 decipol is the pollution from 2 olf at 10 l/s (or 1 olf at 5 l/s). Hence, the relationship between PD and decipol was easily calculated. Nevertheless, early psychophysicists found that the relationship between a perceptual measure of a chemical substance and its concentrations is not linear. Indeed, Fanger acknowledges that 2 decipol is not necessarily perceived to be twice as strong as 1 decipol even though it is twice the "perceived air pollution". As a consequence of these assumptions, the decipol scale must be one of varying intervals (of odour perception) which means one decipol is not necessarily the same as another. The assumption of linearity is fundamental to the olf/decipol methodology as it implies decipols (and olfs) are additive. If the decipol scale is non-uniform then, for example, the difference between 10 and 5 decipol would not equal the perceived pollution, and corresponding olfs, represented by the difference between 20 and 15 decipol. Thus, the relative air pollution contribution from people, the building and ventilation system cannot be separated out by simple subtraction as suggested by the European report and may lead to overestimating the pollutant level.

In most psychophysical experiments, the researcher examines the effect of an objectively measured stimulus on a subjectively measured variable. The error of any derived relationship is then attributed to the subjective dependent variable. In the research described here neither the response (perceived odour in decipol) nor the stimulus (olfs) are objectively measured. All the subjects, ie "standard persons", in the original studies were Danish students aged 18-30 years, but there is no reason to expect odour perception or the bioeffluents produced by different cultures to be the same. Figure 1 shows that cultural, and gender, differences may result in up to a 10% error in PD. Ventilation rates based on studies in Denmark are therefore not necessarily appropriate to other countries.



(Reproduced from Iwashita *et al*, 1990)

Figure 1:

Fanger et al discovered that, due to the high pollutants in building materials, 34% of a panel were still dissatisfied with the indoor air quality when the ventilation rate was greater than 10 l/s. A misinterpretation of the olf/decipol methodology could result in increases in ventilation rates and higher energy consumption. However, Fanger suggests that when controlling indoor air pollution we should restrict the sources of pollutants (olfs) rather than increase the ventilation rate. Indeed, increasing the ventilation rate could result in a higher pollution load emitted from the HVAC system, particularly if it has not been serviced or adequately cleaned. Nevertheless, selecting and installing less polluting building materials is not an easy task, particularly as a retrofit solution.

In summary, the olf/decipol methodology offers the possibility of accounting for both human and non-human pollutants when assessing air quality. However, the method is still undergoing development and has not been properly evaluated. As misinterpreting an assessment based on this method could lead to unnecessarily high ventilation rates and energy consumption, its application should be delayed.

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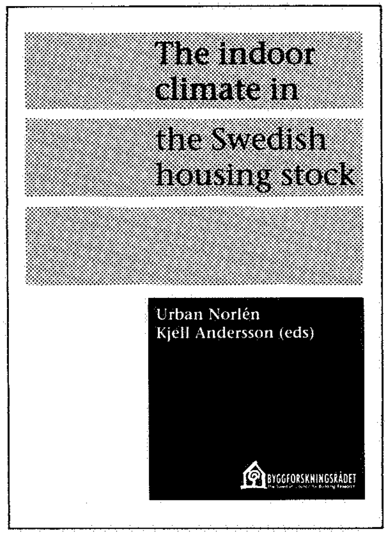
The Swedish Housing Stock

by Urban Norlén and Kjell Andersson (eds)
(Review and Summary)



This report, which describes the indoor climate in Swedish residential buildings, is based on a nationwide survey (the ELIB study). With the help of a postal questionnaire survey, almost 20,000 residents in about 3,300 single-family houses and multi-family buildings have given an account of their experiences of and feelings about their indoor climates. Inspections and measurements in just over 1,100 of the residential buildings have yielded a technical description of the indoor climates.

The survey provides a basis for judging what indoor climate defects and deficiencies exist in the national housing stock, their size and location in the housing stock and who in the population are exposed to them. The following general conclusions have been drawn concerning indoor climate in the Swedish national housing stock:

- Ventilation is poor in Swedish dwellings
- The indoor temperature is on average higher in multi-family buildings than in single-family houses
- The air is dry in more than one third of the apartments in multi-family buildings
- Formaldehyde levels are low
- Radon levels are higher than the limit for existing buildings in 90,000-200,000 dwellings
- Persons suffering from allergies and residents in new, large multi-family buildings are most troubled by defects or deficiencies in the indoor climate
- Between 600,000 and 900,000 Swedes are exposed to indoor climates that can affect their health and well-being

Published by: Swedish Council for Building Research, Stockholm, Sweden,
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Distribution: Svensk Byggtjaenst, S-171 88 Solna, Sweden, Approx price: SEK 280.

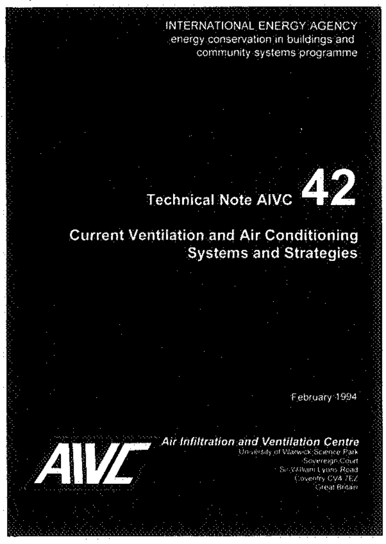
Three new Technical Notes from the AIVC

Current Ventilation and Air Conditioning Systems and Strategies by Mark J Limb

AIVC Technical Note 42 (February 1994)

The goal of this report is to promote a wider understanding of the choices of ventilation systems and strategies. It is aimed at building professionals, designers, architects, researchers and their clients. Its purpose is to generate a deeper understanding into why particular systems and strategies are chosen, and how best to provide the required ventilation or full air conditioning. The classification of systems throughout this report should assist the reader in understanding the role of each system in achieving the stated goals.

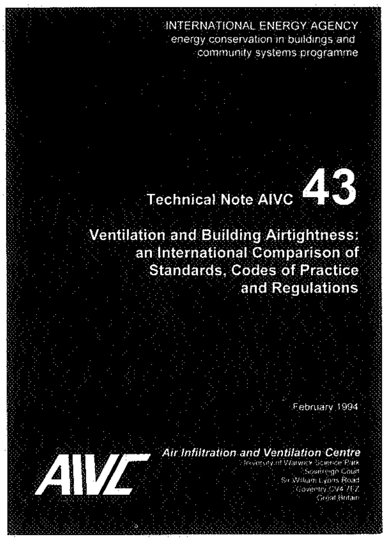
Chapter headings include: Changes in ventilation provisions since the 1970's; The choice of ventilation strategy for dwellings; The choice of ventilation strategy for commercial developments; Classification of dwelling and commercial ventilation strategies and systems; Factors to consider when selecting a ventilation strategy.



Ventilation and Building Airtightness: an International Comparison of Standards, Codes of Practice and Regulations by Mark J Limb

AIVC Technical Note 43 (February 1994)

The document is intended for use as a reference document to all those involved in ventilation and building research. It summarises available airtightness and minimum ventilation rate requirements in the member countries of the Air Infiltration and Ventilation Centre. It also examines a number of indoor air quality standards. Where uniformity exists in the way the standards are expressed some analysis has also been included. The data contained in this report are also available in database format.



Chapters include:

- Airtightness requirements; whole building airtightness and component airtightness
- Techniques for measuring airtightness
- Minimum ventilation rate requirements; ventilation for basic needs; ventilation to remove specific pollutants
- The future development of ventilation standards.

An appendix lists requirements and standards.

An Analysis and Data Summary of the AIVC's Numerical Database By Malcolm S Orme

AIVC Technical Note 44 (March 1994)

The Air Infiltration and Ventilation Centre's Numerical Database has been developed in response to a need to establish a core of numerical data suitable for design purposes and model validation. It has also been developed to provide a focus for data derived from related International Energy Agency projects. Source information is contained within a computerised database from which direct searching for specific material is possible. The purpose of this report is to present an analysis of key database material which may be used for design purposes.

Data have been derived from as wide a range of sources as possible. Many organisations have contributed to the data presented. By combining information from these many sources, it has been possible to consider a far wider range of operating conditions than would be possible by using the results from a single set of measurements.

This report and analysis is presented in three sections; these cover

Section 1: Component Leakage Data

Section 2: Whole Building Leakage Data

Section 3: Wind Pressure Evaluation

Data are presented as a summary of information contained within the database. Most information is presented in the form of median, upper and lower quartile values. Wherever possible, relevant standards and recommendations for building or component performance are referenced.

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Building Environmental Performance: Facing the Future: 2nd BEPAC Conference
5-8 April 1994
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Contact: Mrs Rhona Vickers, AIVC, Sovereign Court, Sir William Lyons Road, Coventry CV4 7EZ

ECEMEI
European Congress on Economics and Management of Energy in Industry
5-9 April 1994
Estoril, Lisbon, Portugal
Contact: ECEMEI, c/o Prof Albino Reis, Rua Gago Coutinho, 185-187, 4435 Rio Tinto, Portugal
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Denmark

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

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

Finland

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Germany

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Netherlands

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New Zealand

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Sweden

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