

## 1<sup>ère</sup> session

### Caractérisation de la qualité de l'air intérieur dans les écoles

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**Indoor air quality and ventilation  
in some schools in England**

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## Introduction

There are 21,500 maintained schools in England. Around 18,000 are primaries (children 5 to 11 years) and 3,500 are secondaries (children 11 to 18 years). They are a very valuable national asset and yet six in every seven schools were built more than 25 years ago (DfES 2003). The government are committed to a programme of rebuilding and renewal over a 15 year period from 2005/06 to ensure that secondary education has facilities of 21<sup>st</sup> century standard. Substantial new investment in primary school buildings in the period is also planned.

The government plan to devolve about £3 billion in 2005/06 to local education authorities and schools and a further £2.2 billion to promote a step change in the quality of provision under the 'Building Schools for the Future (BSF) programme ([www.bsf.gov.uk](http://www.bsf.gov.uk)). Exemplar designs aimed at improving the design quality of school buildings have been created. This guidance adds to the Construction Standards that have been set by the Department for Education and Skills (DfES) over many years and since 2001 schools ceased to have exemption from the Building Regulations. Standards such as Building Bulletin 87 (DfES 2003a) are used by Building Control Bodies as the normal means of compliance with the Building Regulations for schools. The proposed amended version of Approved Document F (AD F) (Ventilation) of the Building Regulations refers to Building Bulletin 87 for guidance on ventilation provision for schools (ODPM 2004). The July 2004 consultation document on revision to AD F referred to a new DfES publication in preparation and a draft document, Building Bulletin 101, has subsequently been released for comment (DfES 2005). The intention is that the amended AD F and Building Bulletin 101 will come into force in January 2006.

## Ventilation requirements

Ventilation guidelines for schools are included in the legally binding School Premises Regulations, 1999. The guideline for minimum ventilation rates in teaching areas is 3 l/s per person for each of the maximum number of persons that the area will accommodate. In addition it is recommended that the ventilation approach used in any school building should be capable of providing an enhanced rate of at least 8 l/s per person. All washrooms shall be capable of being ventilated at a rate of at least 6 air changes per hour and adequate measures are required to remove noxious fumes in areas such as kitchens where they are generated.

The DfES has drawn up guidance on good quality design for adaption of existing buildings as well as new building projects (DfES 2002). Recommendations for good design are provided under four topics; Spaces for today and tomorrow, The learning environment, Thoughtful planning and Sustainability. Ventilation is one aspect of The Learning Environment and two headline criteria are;

- Aim for natural ventilation where possible,
- Balance the comfort needs of those with special needs and others.

This document provides some general advice on ventilation and indoor air quality (IAQ) as follows:

- While natural ventilation is preferable, automatically opening vents and windows may be needed as school users often do not open windows. Some form of mechanical ventilation is advised by some designers.
- Air conditioning should be avoided because of high cost and energy consumption.
- Good IAQ is a key design issue; a good target is between 1,000 and 1,500 ppm carbon dioxide (CO<sub>2</sub>).

It refers to Building Bulletin 87 for further guidance which sets out requirements of the School Premises Regulations, Construction Standards and provides some further guidance on IAQ issues (DfES 2003a). For example it says that for normal classroom occupancy a CO<sub>2</sub> concentration of 1,000 ppm corresponds to a ventilation rate of about 8 l/s per person. It notes that given that natural ventilation is driven by the combined wind and stack effect, the rates of ventilation should be calculated to give good IAQ at typical conditions of wind speed and inside to outside temperature difference. For classrooms designed to be ventilated by openable windows, trickle vents should be fitted. Use of heat recovery is encouraged where mechanical ventilation is applied. The recommended design temperature is 24 ± 4°C and it is undesirable for peaks to exceed 28°C for more than 80 occupied hours per year.

Except for CO<sub>2</sub>, there are no air quality standards/guidelines for indoor pollutants in Building Bulletin 87. A Department of Health expert committee has recommended IAQ guidelines for a number of air pollutants in homes including formaldehyde, benzene, nitrogen dioxide (NO<sub>2</sub>) and carbon monoxide (CO), and state that exposure to air pollutants in nurseries and schools may form the subject of a future paper (DH 2004).

The draft Building Bulletin 101 refers to proposed performance based standards in the draft AD F which set concentrations not to be exceeded for humidity, NO<sub>2</sub>, CO, total volatile organic compounds (TVOC) and ozone. There is an additional proposed requirement that the concentration of CO<sub>2</sub> in all teaching and learning spaces when measured at seated head height and averaged over the whole school day should not exceed 1,500 ppm. The minimum supply of external air shall not be less than 3 l/s per person in all teaching and learning spaces when they are occupied and there should be a capability for 8 l/s per person. For classrooms a daily average of 5 l/s per person is considered suitable. It is noted that there is a strong relationship between ventilation and acoustics, particularly with natural ventilation. Careful consideration needs to be given to the interaction of the ventilation strategy and the acoustic performance (see Building Bulletin 93) of the building.

BRE has developed widely used schemes for assessing the environmental impact of new building developments. One of these schemes is for schools. BREEAM Schools includes criteria for Health and Well Being (BRE 2005). Included in the criteria is the requirement for the design team to show that the natural ventilation system will provide sufficient draught free air to provide;

- background ventilation to allow dilution of pollutants from outgassing of volatile organic compounds (VOCs),
- adequate fresh air to meet needs throughout year sufficient for occupancy load and internal pollution load,
- higher rates of ventilation to allow removal of short term odours.

Also in a sub-section on VOCs, there are criteria to encourage use of finishes and fittings with low solvent content; the design team must provide evidence that products with VOCs have been avoided wherever possible and justify any use of products containing VOCs. In a sub-section on indoor air, credit is awarded for air intakes and openable windows being located away from sources of external pollution.

## **Studies of IAQ in UK schools**

During 2001 BRE undertook a literature review of ventilation and IAQ and found that there was little information concerning UK schools. BRE has been involved in a large number of air quality investigations in buildings and a number of these have involved schools with issues relating to odours and occupant complaint (Brown et al. 1993, 1996). There was however no systematic study of ventilation and IAQ.

Since 2001 BRE has undertaken two quite major studies of IAQ in schools and these are briefly outlined below.

### *Ventilation and IAQ in primary schools built since 1995.*

This study of eight schools in England was undertaken for the Office of the Deputy Prime Minister ODPM. Two classrooms in each school were investigated for one week during winter months. All the schools were naturally ventilated and the study occurred under normal conditions of occupancy. The following IAQ parameters were measured; VOCs, CO, NO<sub>2</sub>, aldehydes, particulate matter, fungi and bacteria, dust mites, temperature, humidity, ventilation rate and CO<sub>2</sub>. Ventilation rates were measured during afternoon lessons over a 45 minute period using the perfluorocarbon tracer (PFT) technique. Some parameters such as CO<sub>2</sub> were continuously monitored throughout the whole school day.

The study found that approximately 50% of the ventilation rates measured by PFT were below the recommended minimum rate of 3 l/s per person. In most cases the schools were capable of achieving the enhanced 8 l/s per person. Daily mean concentrations of CO<sub>2</sub> exceeded 2,100 ppm in 10% of cases suggesting that ventilation was not adequate. Approximately 60% of CO<sub>2</sub> values were between 1,000 and 2,100 ppm implying that ventilation rates were at least 3 l/s per person at these times. In general IAQ parameters were within guidelines for other indoor environments set by a number of groups, but those for TVOCs, bacteria and fungi were exceeded on some occasions. Inadequate use of openable windows was the main reason for poor ventilation in classrooms. Further details of the study are given in a BRE publication (BRE 2005a).

### *Indoor air quality in a primary school following refurbishment*

The air quality in an Infant and Nursery school in England was investigated over a 12 month period following refurbishment. The original school buildings were constructed in the 1970s and were closed for refurbishment in 2001. Prior to re-occupation, BRE undertook an indoor air quality survey involving the measurement of volatile organic compounds (VOCs), aldehydes and combustion gases.

After the school re-opened in September 2003 diffusive samplers were used to measure VOCs and aldehydes in all staff offices, teaching areas and the main hall over a full school year. In addition the staff was provided with questionnaires to record any symptoms that may be related to poor indoor air quality. Results of the monitoring were compared with available guidelines for IAQ and concentrations measured in UK homes and offices during other BRE studies. The study identified a potential for achieving improved air quality by use of low emitting products. The study is described further in a conference paper to be published during 2005 (Crump et al. 2005).

## Conclusion

Ventilation and IAQ are recognised in the UK as important parameters for the provision of an appropriate environment for effective learning. Requirements for ventilation are provided in guidance referenced in the Building Regulations. Currently there are no guidelines for levels of indoor pollutants in schools in the UK although there are for homes. However guidance on environmental design and the BREAM scheme encourage design for good indoor air quality and proposed amendments to the Building Regulations incorporate performance requirements that include IAQ parameters. There is a need for further studies to evaluate the IAQ in existing schools and within the new schools to be constructed under the BSF programme.

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