



Figure 1

Carbon Dioxide Levels and Ventilation Rates in Schools

Introduction

Ventilation within schools is important for at least two reasons. Firstly, there is the question of air quality and its effect on health and performance. Secondly, it is a heat loss path. There is varying evidence on the effect of low ventilation rates on performance and health and further studies have been carried out at these schools to identify the impact. Ultimately it will be concerns in this area that will determine ventilation rate guidance.

Recommended fresh air supply rates for school classrooms are country-specific. For the UK, the recommendations are enshrined in the School Premises Regulations and repeated in Building Bulletin 87 (BB87), which requires a background fresh air supply rate of 3 litres per second per pupil (l/s/pupil) with the capacity to supply 8 l/s/pupil. The value of 8 l/s/pupil is used because it implies the concentration of CO₂ in a fully occupied classroom can never exceed 1000ppm, however long the room is occupied.

Measurements

In the following, measurements of CO₂ levels in seven classrooms in four naturally ventilated primary schools are reported. Measurements were taken for at least two days, but mostly for one week, in each classroom during the heating season. The time-varying ventilation rates within each space were then estimated from these measurements. This method was chosen for three reasons:

- It avoids possible concerns by staff, pupils and parents over the use of an artificial tracer gas;
- It gives the *true* ventilation rate in that it automatically accounts for the ingress of air from other parts of the building;
- It can be used during occupied periods to give time-varying results. This latter point is crucial and contrasts this work with other studies where only unoccupied non-varying ventilation rates were obtained.

In order to prove if the rooms could be efficiently ventilated, “purge ventilation” experiments were carried out in each classroom. During this time the classrooms were unoccupied and a modest number of windows were opened.

Figure 1 shows some of the data collected over four and half days of occupied periods at St. Minver Primary School, Cornwall, Year 5 and the ventilation rates estimated for the CO₂ time series. The solid line represents the CO₂ concentration, the squares the estimated ventilation rates and the dashed line the one-hour moving average of these rates.

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Problem

The experiments show CO₂ concentrations, which are far beyond the implied guideline value of 1000 ppm. In some classrooms the level exceeded the range of the detector (4000ppm). Calculated air supply rates vary from unacceptably low levels to those that are in line with guidance. These acceptable rates and those found during the “purge ventilation” experiments, show that the surveyed classrooms have the potential to provide the level of fresh air required by BB87. However, as mechanical ventilation systems are not fitted in any of the classrooms, the occupants are responsible for the performance of these naturally ventilated spaces.

From these experiments we can conclude the following:

- The average “occupied” ventilation rate was 0.84 ac/h (1.38 l/s/pupil), with a minimum of 0 ac/h and a maximum of 5.19 ac/h (8.55 l/s/pupil);
- The average CO₂ concentration during the occupied period was 1957 ppm, the maximum was above 4000 ppm;
- The average “unoccupied” ventilation rate was 0.53 ac/h, with a minimum of 0 ac/h and a maximum of 4.38 ac/h;
- Adequate fresh air was not being provided.

The experiments showed that adequate ventilation could be provided by the classroom designs in question. Anecdotal evidence from the classroom teachers suggest that the reason enough fresh air is not being provided is firstly the siting of windows and secondly that the staff do not make use of them.

This evidence is strengthened by consideration of Figures 2 and 3.



Figure 2 Topsham School, Year 6

In Figure 2 we see that the pupils in the first row might be exposed to high levels of draught if the windows were opened and this effect was indeed reported by the teacher in question. In Figure 3 we can see that it would be very difficult to open the windows.



Figure 3 St. Minver School, Year 5

Clearly the rooms as designed are capable of supplying enough fresh air to keep CO₂ levels within guidance, the only problem is that for the two reasons mentioned above, staff are not availing themselves of this capability. Any successful solution needs to be able to supply air at a low velocity (so draughts are avoided) and possibly be in part automatically controlled (to ensure it is used). However, the experiments also show that if this can be done, a mechanical ventilation system is not required.

Adverse Effect

A later study was carried out at the same school to investigate whether inadequate ventilation rates might have an impact on pupil performance and learning outcome. Using standard, computerised tests of cognitive function, this study demonstrates that the attention processes of school children are significantly slower when the level of CO₂ is high. Thus in a classroom where CO₂ levels are high, students are likely to be less attentive and concentrate less well. This adverse effect is similar to that observed over the course of a morning when students skip breakfast!

Passivent Solution

As a leading provider of natural ventilation solutions, Passivent have participated in some of the most important research projects in the natural ventilation field. Along with research, design and advisory services Passivent also manufacture a range of automated façade ventilation louvres that allows natural ventilation to be integrated within glazed facades or walls. These devices include control systems that will monitor the indoor air quality and maintain recommended ventilation rates automatically.