Carbon dioxide control of ventilation

AIVC

A Demonstration Project Final Report shows the benefits and pitfalls of controlling ventilation systems through the measurement of CO_2 in the exhaust.

In many buildings the levels of occupancy can vary considerably and, at times of low occupancy, ventilation can become excessive and result in the unnecessary extraction and loss of warm air. This, in turn, can lead to the unnecessary consumption of heating fuel.

To determine the fuel cost savings that would result from reducing ventilation rates during periods of low occupancy, the Rank Organisation retrofitted a variable fresh air ventilation system, controlled by a carbon dioxide detector, at a social club and at a cinema.

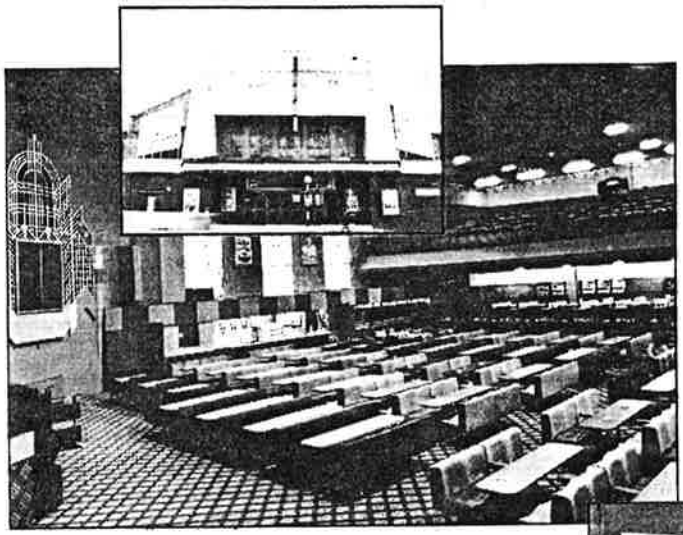
People produce, typically, 12·6 to 72 litres/hour/person of CO_2 as part of their normal breathing process and, for a given activity level, the amount of CO_2 generated in a building depends directly upon the number of people present. In the bingo and social club and at the cinema, this CO_2 is removed continuously by mechanical ventilation and natural air infiltration.

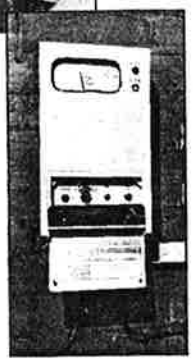
In a CO_2 sensor-controlled variable ventilation system, the supply of extract flow rates are adjusted to maintain pre-set levels of residual CO_2 within the building. When the amount of fresh air supplied in the building by the ventilation system is reduced by the CO_2 sensor, the heating load is also reduced and fuel is thus saved.

The two buildings chosen for testing the variable ventilation system were the Top Rank Club at Hounslow, London, and the Odeon Cinema, Leicester.

The Top Rank Club in Hounslow has a full fresh air ventilation system provided by supply and extract fans located at opposite ends of the building. These fans are switched off and on manually. Heating is by two 292 kW gas-fired boilers. Most of the heating load is covered by a fresh air heater battery installed in the supply ductwork, and background radiators.

The club has a seating capacity of approximately 1500 distributed between front stalls, rear stalls and circles. It remains open nearly every day for about 11 hours, although most people attend only the main afternoon or evening games. Occupancy is therefore highly variable.





Above: The Top Rank Club in Hounslow, and *right* the CO_2 monitor.

The Odeon cinema in Leicester is divided internally into one large auditorium comprising the old circle and front stalls seating approximately 1200 people, and two small auditoriums of approximately 110 seats each which were originally the rear stalls of the old main auditorium. Programmes run almost continuously every day from 13 00 to 22 30 hours, although occupancy varies.

Heating at the cinema is provided by two 440 kW oil fired boilers. A radiator circuit provides background heating and a heater battery in the full fresh air ventilation system provides space heating.

The variable fresh air ventilation system and CO_2 sensor installed at both sites, (see figure 1) was installed by Information Transmission Limited and consists of variable ventilation plant controlled by a CO_2 sensor. The sensor continuously samples air in the extract duct (or directly from the auditorium) and measures the concentration of CO_2. If the concentration exceeds a pre-set value, usually 700 to 1000 ppm, dampers in the supply and extract ducts open to increase the ventilation air throughput.

By comparison with this pre-set of CO_2 concentration, the recommended upper limit value is 5000 ppm and the normal external concentration of CO_2 in the atmosphere is 300 to 350 ppm. During periods of low occupancy the damper is closed to reduce the total flow of air through the building.

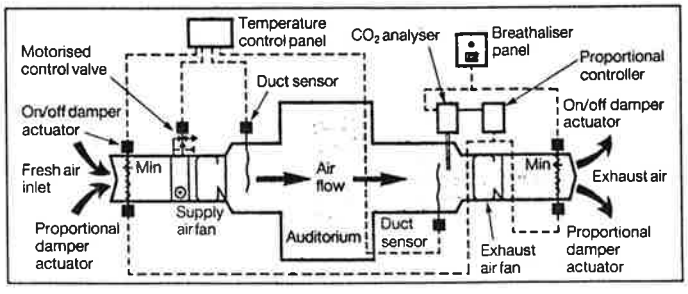
There are four sets of dampers in the exhaust and supply ducts. Three are controlled by the CO_2 sensor and the fourth opens fully, immediately the fans are switched on, to prevent damage to the ducts and to provide a minimum amount of fresh air irrespective of the number of people in the building. At night all dampers are fully closed to prevent heat losses between convective ventilation and also to provide some frost protection to the heater batteries.

The installation of air recirculation system, which would have reduced costs, was not practical at either the club or the cinema due to the large distance between the supply and extract ducts.

When the amount of fresh air drawn into the building is reduced, the heating load is also reduced and fuel is thus saved. But if the building temperature is allowed to rise, fuel savings will not be achieved. Effective temperature control is therefore essential.

At both sites the temperature of the fresh air supply is thermostatically controlled by a separate temperature controller that monitors the temperature within the auditoria: if the internal temperature drops, eg as a result of increased heat losses, the set point temperature of the fresh air supply is increased. Typically, the controller is set to provide air at 22°C when the auditoria are at 22°C, and 42°C when the temperature in the auditoria falls to 17°C.

The radiator circuits were uncontrolled however and this reduced the overall effectiveness of the temperature control and contributed to low fuel savings in the first year of operation. This mode of fan operation reduced the performance of the system because the amount of fresh air supply prior to conversion to variable ventilation was effectively reduced and because the system required both fans to be operated. As a result of experience gained during the monitoring period, the system was rewired so it was only neces-



Above: Diagrammatic layout of ventilation plant and controls.