Four cell ventilation and air movement measurements using a new multiple tracer gas technique

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Introduction

This article briefly describes a new piece of apparatus, recently developed at UMIST, which can be used for the determination of ventilation rates in, and air movement rates between, four interconnected cells.

Description of Technique

Ventilation and air movement research has been in progress at UMIST for over eight years. In this time, the tracer gas detection equipment used has developed from a simple, single separation column gas chromatograph (1) to a twin column gas chromatograph (2) which is able to analyse an air/tracer gas sample within 45 seconds for the case of three tracer gases. However, this system cannot fully cope with the four cell, four tracer gas situation, since, in order to achieve the maximum one minute sampling interval required for successful mathematical analysis of the data (3), tracer gas peak resolution is reduced to an unacceptable level at low tracer gas concentrations. It has therefore been necessary to develop a new piece of equipment in order to facilitate the satisfactory use of four or more tracer gases.

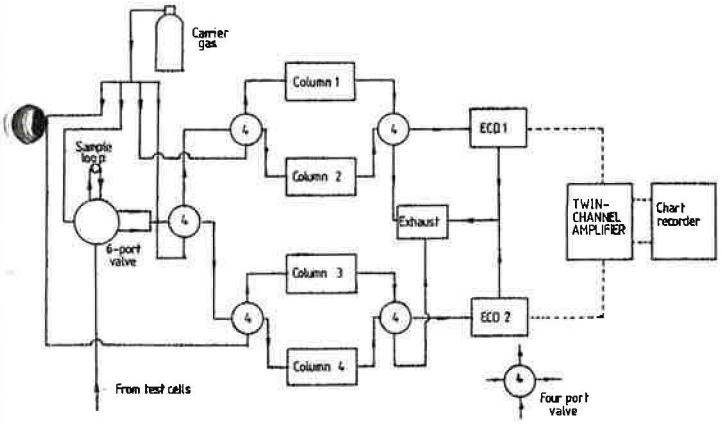

Figure 1: Measurement Equipment

The equipment is shown in Figure 1. It consists of an Analytical Instruments model 505 portable gas chromatograph, as per the previous two pieces of equipment. However, in this case, the modifications made are on a significantly greater scale. The gas chromatograph now has two electron capture detectors fitted in parallel, which are capable of being operated both simultaneously and independently. The signal amplifier/invertor board originally fitted has been replaced by a custom made twin channel board. Each electron capture detector is connected to a pair of separation columns in the same manner as the parallel column equipment. Five four-port valves are used to direct sample flow through the system. Later work with the parallel column equipment showed that problems of pressure equalisation in the system were obviated if the system was pressurised by means of a pump at its front end, instead of using a pump to suck gas through: the same idea is used in this apparatus.

The gas chromatographic separation columns used are of 6 mm internal diameter, and 3 metres length. The packing is 10% squalane on a ceolite (non-acid washed) base. In order to ensure the best possible response match between the columns, the column preparation and operating procedure described by Irwin and Edwards (2), is again used. When in operation, the columns are immersed in a thermostatically controlled water bath and stirrer unit at a temperature of 40°C: apart from minimising baseline drift problems, this practice also helps to improve column response match. During laboratory calibration checks, the maximum response difference observed between the two electron capture detectors at the same tracer gas concentration was not greater than 0.5%.

A range of tracer gases have been assessed for use in four cell measurements, (4). The gases chosen are Freons 13B1, 12, 114 and perfluorocarbon PP1. Using these four gases, one air/tracer gas sample can be analysed in one minute: this means that the apparatus can receive one air/tracer gas sample every 30 seconds, since the use of parallel detectors doubles the available time for which detector output can be monitored for a given sample. This extra time reduces the urgency for rapid tracer gas peak throughout, and hence improves peak resolution at lower tracer gas concentrations.

Discussion

The test cell arrangement used during the commissioning program is shown in Figure 2. The kitchen, living room/lobby and dining room have been taken as separate cells, whilst the whole upstairs has been taken as one cell. The tracer gases are injected as follows: Freon 12 in the dining room (gas A); Freon 13B1 in the kitchen (gas B); PP1 in the living room/lobby (gas C); Freon 114 upstairs (gas D). A set of tracer gas growth/decay curves measured in the dining room during a typical test is shown in Figure 3, whilst the complete set of calculated ventilation rates and interzonal air flows for that same test are given in Table 1.

	1	2	X	3	4
N_x (ach)	4.33	6.83		3.40	1.63
Nett airflow to/from outside (m^3/hr)	+40	+45		−5	−80
F_{1x} (m^3/hr)	x	80		20	30
F_{2x} (m^3/hr)	65	x		100	40
F_{3x} (m^3/hr	15	70		x	150
F_{4x} (m^3/hr	10	10		120	x

Table 1: Ventilation and airflow rates

At the present time, the authors do not have access to a four cell controlled environment system, and therefore validation of the measurement of the technique is not possible. However, on the basis of validation exercises conducted for the cases of two and three interconnected cells, it is expected that the likely error in calculated air flows will be of the order of +/–15%.

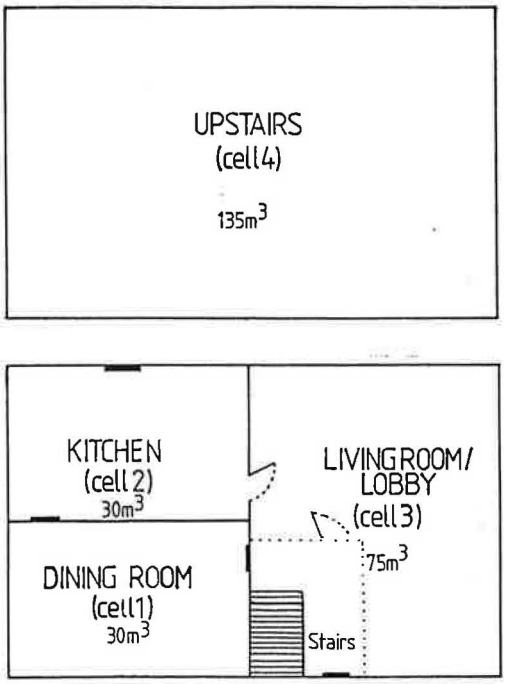

Figure 2: Test Cell Details

Conclusions

The prototype parallel column apparatus is currently undergoing modifications in order to improve its performance. There are a substantial number of tracer gases available which are suitable for use with this apparatus, (4)

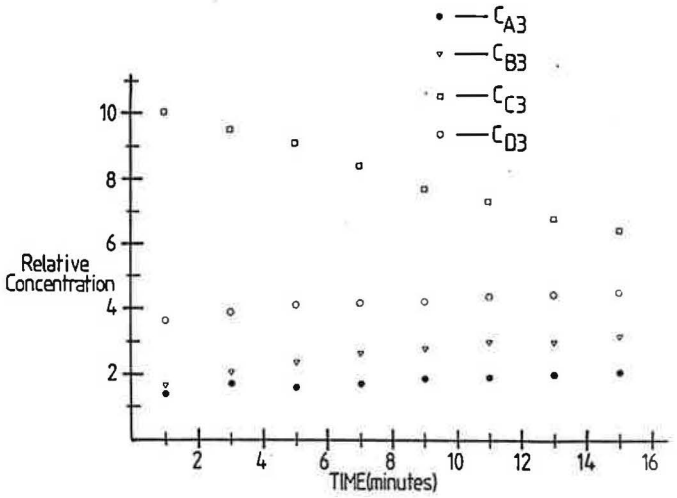

Figure 3: Tracer concentrations in dining room (cell 3)

the current controversy concerning the ozone layer notwithstanding. With careful optimisation of column operating conditions, this apparatus could be used with five or more tracer gases. This is obviously well in excess of the capability required for air movement studies in domestic premises, but offers great potential in the field of air movement measurement in large spaces.

References

1. S.J. l'Anson, C. Irwin, and A.T. Howarth, Building and Environment, Volume 17, No 4, pp 245-252, 1982.
2. C. Irwin and R.E. Edwards, BSERT, Volume 8, pp 91-96, 1987.
3. R.E. Edwards and C. Irwin, Proceedings of Roomvent '87, Stockholm 1987.
4. R.E. Edwards & C. Irwin, Building and Environment, (to be published).