The Validation of a Multiple Tracer Gas Technique for the Determination of Airflows Between Three Interconnected Cells

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Introduction

This paper describes the extension of the previously described UMIST technique for the determination of airflows between two interconnected cells to the case of three connected cells, and gives the results obtained for a series of validation experiments carried out under controlled conditions.

Sampling system

The tracer gas sampling and measurement system used is well documented, (for example references 1 and 2). Briefly, it consists of an Analytical Instruments Model 505 portable gas chromatograph, modified so as to be fitted with two chromatographic separation columns fitted in parallel. A system of sampling valves is used such that samples passing through each column can be passed alternately to the electron capture detector in the chromatograph. A more rapid sampling rate is attained by virtue of the fact that the 'dead time' associated with waiting for a sample to pass through a single column is eliminated.

The separation columns used are of stainless steel, being 3m in length, 6mm internal diameter, and with a column packing of 10% squalaine on a CNAW support. For two cell measurements, these columns are held at 30°C in a thermostatically controlled water bath/stirrer unit. Using Freon 12 (dichlorodifluoromethane) and Freon 114 (dichlorotetrafluoromethane) as tracer gases, a 30 second sampling interval is achieved. The third tracer gas used in this piece of work is B.C.F. (bromochlorodifluoromethane). If the water bath temperature is increased to 50°C, then a sampling interval of 45 seconds for three gases can be achieved, without loss of peak resolution.

Test procedure

The environmental chamber facility used in reference 1 was again used for this piece of validation work. To create a three-chamber arrangement, one of the chambers was partitioned by means of a PVC sheet. The volumes of the cells used are shown in Figure 1. Air movements between the three cells were induced by means of ducted low speed fans, in combination with the air supply system feeding the chambers. Air velocities in the supply ductwork were measured using a Pitot tube and inclined-tube manometer, whilst the air velocities between cells were measured using a hot wire anemometer probe. The tracer gases were injected remotely into all cells from cell 1, using PVC tubing.

Test results and analysis

Initially, a simple single chamber ventilation rate measurement was taken using all three tracer gases. This is now adopted as a standard check on performance of the separation columns and the detector/sampling system. Three series of measurements were then carried out, twelve tests in all.

Typical results of the multi-chamber airflows measured are shown diagrammatically in Figures 1 to 3 inclusive where the measured airflow rates (m^3/hr) are in brackets.

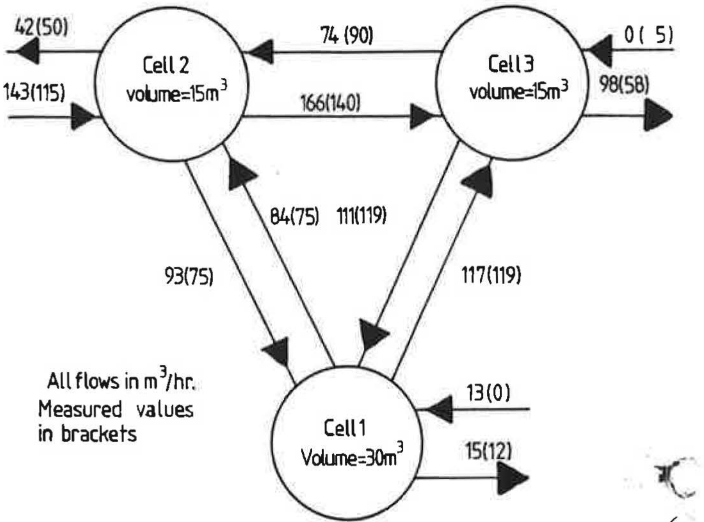

Figure 1. Comparison of measured and calculated airflows (typical of series 1)

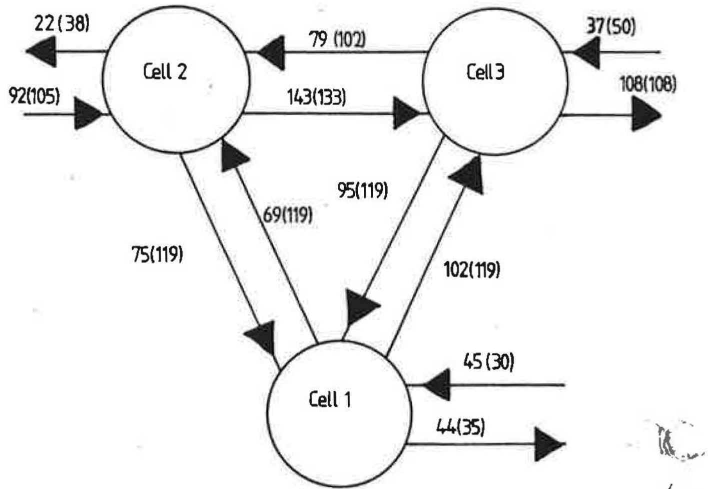

Figure 2. Comparison of calculated and measured airflows (typical of series 2)

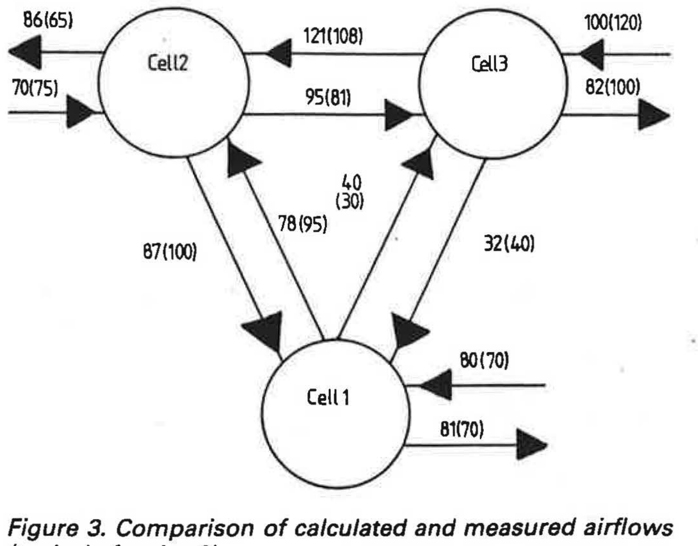

Figure 3. Comparison of calculated and measured airflows (typical of series 3)

The errors found between calculated airflow rates and measured airflow rates are approximately ± 20%, the effect of these errors on chamber air change rates being about ± 10%. Figure 4 shows the variation of tracer gas concentration with time for chamber 3 during a multiple tracer gas test. It is worth noting that the high air change rates occurring in all chambers cause rapid changes of tracer gas concentration with time; all three tracer gases tending to equilibrium in twelve minutes.

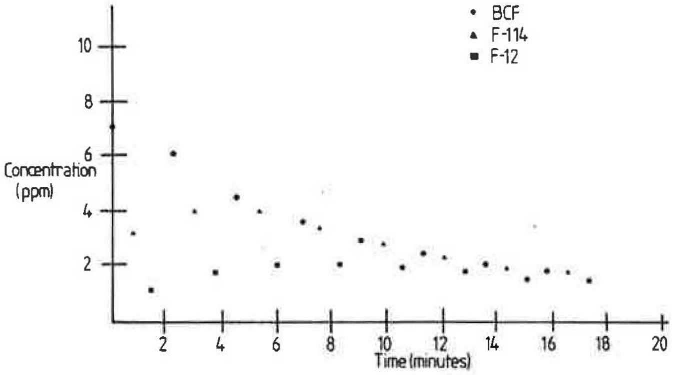

Figure 4. Changes in tracer gas concentrations in cell 3.

Discussion

The magnitude of the chamber connecting airflows was large with respect to the chamber volumes. This encouraged recirculation of tracer gas between connected chambers.

Where two-directional air movement occurs between connected spaces, the shape of the tracer decay curve in the source room will not be a simple exponential function. Defining the shape of the tracer gas concentration/time variations as the sum of two or more exponential functions enables calculation of the cell air change rates and intercell air movements[3].

This 3 cell validation work of the UMIST multiple tracer gas system shows that sufficiently accurate estimations of airflows can be obtained using this method over a period of about 20 minutes.

Acknowledgements

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References

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3. C Irwin. A method of measuring air movements in compartmentalised buildings. PhD Thesis, UMIST, June 1985.

The New Staff at the AIVC

Dr Peter Charlesworth joined the staff of the Air Infiltration and Ventilation Centre on 1 June 1986. He graduated in physics at the University of Lancaster in 1982 and went on to obtain his PhD from the University of Sheffield where he studied convective heat transfer from flat-plate solar collectors. Until taking up the position of Scientist with the AIVC he was involved in research work at Sheffield City Polytechnic, dealing with the development of a tracer gas technique to measure multi-zone air movement in buildings.

Peter is currently working on a guide to techniques for the measurement of air infiltration and air leakage. He is also involved in the collection and analysis of the replies to the AIVC's 1986 survey 'Current reseach into air infiltration and related air quality problems in buildings'.

Emma Young joined the Air Infiltration and Ventilation Centre in May as a school leaver from Easthampstead Park Comprehensive School in Bracknell. She acts as a general assistant to all members of the Centre Staff, with particular responsibility for information and administration services.