Application of Tracer Gas Analysis to Room Habitability Test

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1. Introduction

This article discusses the application of tracer gas methods to industrial hygiene investigations. It introduces the basic concepts necessary to understand the application of tracer gas methods to particular airflow and contaminant movement measurements.

2 The Evaluation of Ventilation Systems Using Tracer Gas Methods

Air change often accounts for a significant portion of the heating or air-conditioning load of a building. It also affects the moisture and contaminant balances in the building. Moisture-laden air passing through the building envelope can permit condensation and cause material degradation. An appropriate level of ventilation is required in all buildings; one should consult ASHRAE Standard 62 to determine the ventilation requirements of a building.

A related technique (Test Method E 779) uses a fan to pressurize the building envelope. Measurements of corresponding air flows and pressure differences across the envelope characterize envelope airtightness as either the air leakage rate under specified induced pressure differences or the equivalent leakage area of the envelope. These factors permit modeling natural air change due to wind and temperature differences. However, direct measurement of natural air change is not possible with Test Method E 779. Test Method E 779 permits comparison of different buildings, isolation of leakage sites, and evaluation of retrofit measures.

2.1 Procedure for the Concentration Decay Test Method

To determine average air change rate, one introduces a small volume of tracer gas uniformly into the zone, ensures a uniform concentration, and then measures tracer gas concentration at known times. One calculates the average air change rate for that period as the difference between the logarithms of the initial and final tracer gas concentrations divided by the time period. When required, one shall obtain additional air samples to test the hypothesis that the air change rate was constant during the test with an optional regression analysis of the logarithms of additional tracer gas concentration measurements. Fig. 1 gives a implified overview of this test method.

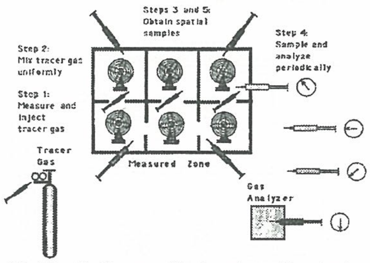


FIG. 1 Simplified Summary of the Apparatus and Procedure for the Concentration Decay Method

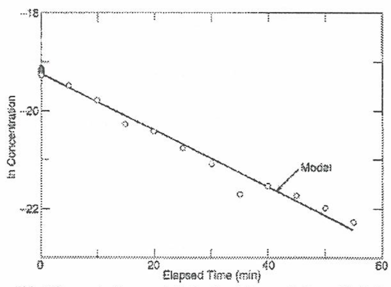


FIG. 2 Concentrations and Estimate of Concentrations Plotted Logarithmically

Plot the data on axes of ln C(t) against t, as illustrated in Fig 2. With the assumption of constant air change, the following relationship holds:

$$\ln C(t) = -At + \ln C(0) \quad \cdots\cdots (3)$$

2.2 Procedure for the Constant Injection Test Method

To determine the average air change flow, inject tracer gas uniformly into the zone at a known, constant rate, ensure a uniform concentration, and then measure tracer gas concentration at known times. Calculate the average air change flow for the measurement period as the product of the tracer gas flow rate times the average of the inverses of measured concentration less a correction for the beginning and ending concentrations. It is not necessary to know the volume of the zone if the beginning and ending concentrations used in the calculation are approximately equal. Test the assumption of constant air change for the time period with an optional analysis of confidence intervals of the tracer gas concentrations after equilibrium has occurred. Fig. 3 gives a simplified overview of this test method.

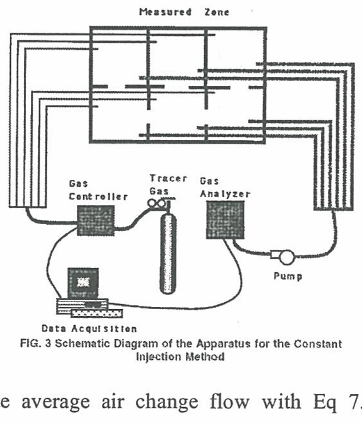


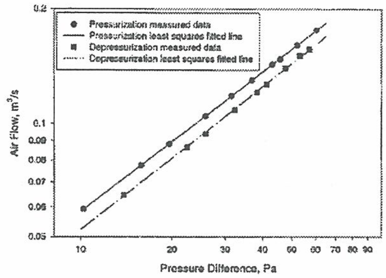
FIG. 3 Schematic Diagram of the Apparatus for the Constant Injection Method

Compute average air change flow with Eq 7.

$$Q = Q_{tracer}\left[\frac{1}{C}\right]avg - \frac{V_{zone}}{(t_2 - t_1)}\ln\left[\frac{C_2}{C_1}\right] \quad \cdots\cdots (7)$$

2.3 Air leakage by mechanical pressurization or de-pressurization

From the relationship between the airflow rates and pressure differences, the air leakage characteristics of a building envelope can be evaluated. Air leakage accounts for a significant portion of the thermal space conditioning load. In addition, it can affect occupant comfort and indoor air quality.



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