# An Automated Air Infilation Measurement System – Its Design and Capabilities – : Preliminary Experimental Results

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## Introduction

Air infiltration has been studied by several researchers. They have been using the decay of a tracer gas in order to measure air infiltration. This technique is used for short term measurements and cannot, without great difficulties, be used for long term measurements. It is also difficult to make accurate measurements of the ventilation rate of individual rooms.

Therefore, a completely automated constant concentration technique has been developed. This technique makes it possible to perform long term measurements simultaneously in a number of rooms.

## Principle of Measurement

The most common tracer gas technique records the decay of a tracer gas. A tracer gas is injected into a room or a whole house and the decay in the concentration of the tracer gas is measured. From these measurements the air change rate is calculated directly. Continuous measurements are difficult to make. When the energy loss caused by air infiltration is to be calculated the ventilation rate must be expressed in $m^3/h$. To convert the results from a measurement the effective volume must be known. This is a number which is often hard to calculate accurately. The required equipment is however rather simple. The only thing needed is a tracer gas analyzer measuring differences in the tracer gas concentration.

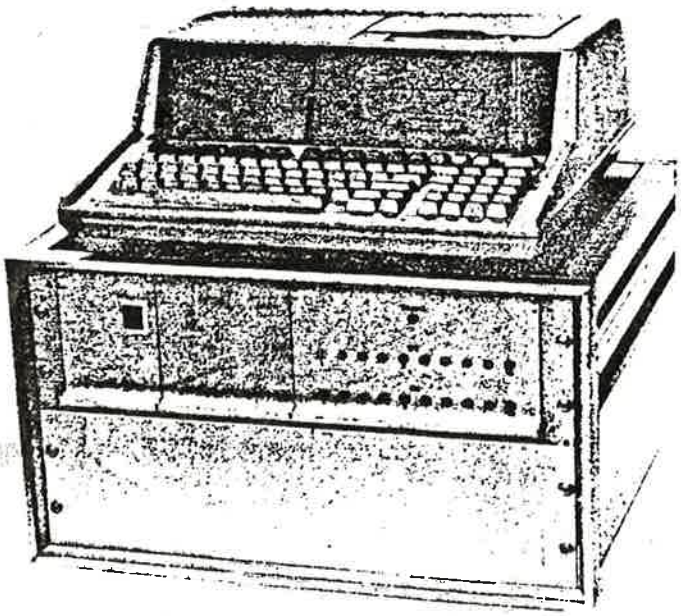

*Figure 1. Controller on top of injection and sampling unit.*

The automated air infiltration measurement system developed at the National Testing Institute maintains a constant concentration of a tracer gas in nine rooms simultaneously. Tracer gas is injected into each room and the concentration is measured in each room. A target concentration is maintained. The result of the measurements is the supply of fresh air to each room. The result is given in $m^3/h$ directly without any estimation of the effective volume.

Long term measurements can be made. The technique requires accurate measurements of the absolute concentration of a tracer gas and of the tracer gas flow. The concentration must remain constant throughout the whole measuring period.

## Description of Equipment

The equipment consists of five components:

1. A controller.
2. A tracer gas analyzer.
3. An injection and sampling unit.
4. Special mixing fans.
5. Apparatus for the calibration of the tracer gas flow.

The system is controlled from a Hewlett Packard 85 microcomputer (see Figure 1). The concentration of the tracer gas is kept constant using a program based on the principle of a PI-regulator. A measuring period is started with a short decay measurement. This is done in order to estimate the ventilation rate and to be able to reach the target concentration in a short time. This time is approximately 45 minutes.

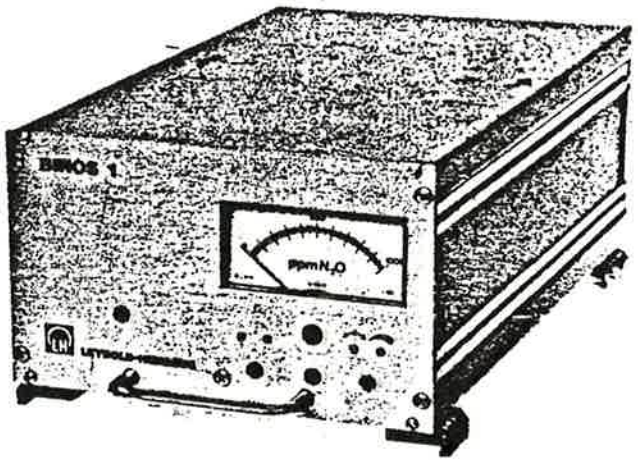

*Figure 2. Tracer gas analyser.*

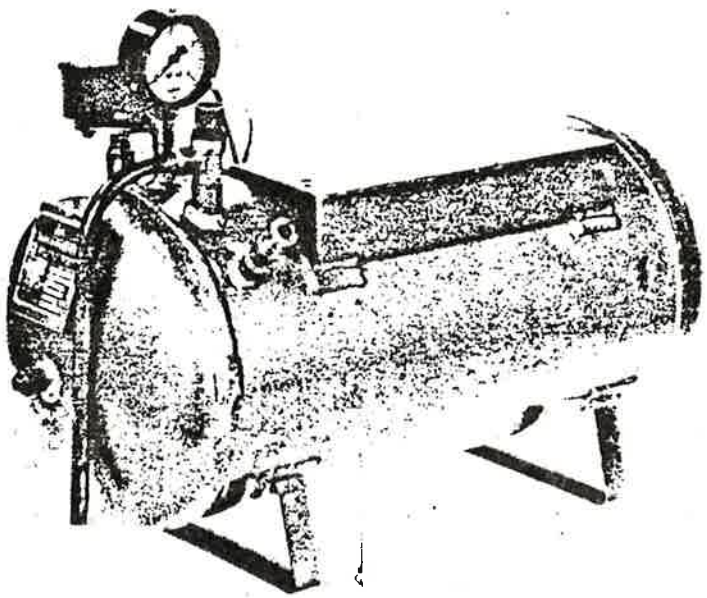

*Figure 3. Tank where the pressure is kept at a constant level.*

The tracer gas concentration is measured using a fast analyzer, a Binos 1 (see Figure 2). Nitrous oxide is used as the tracer gas.

A tracer gas cyclinder is connected to a tank where the pressure is kept constant at 200 kPa (see Figure 3). The tank is connected to the injection side of the injection and sampling unit (see Figure 1 and 4). This unit contains a microprocessor and solenoid valves for injection and for sampling.

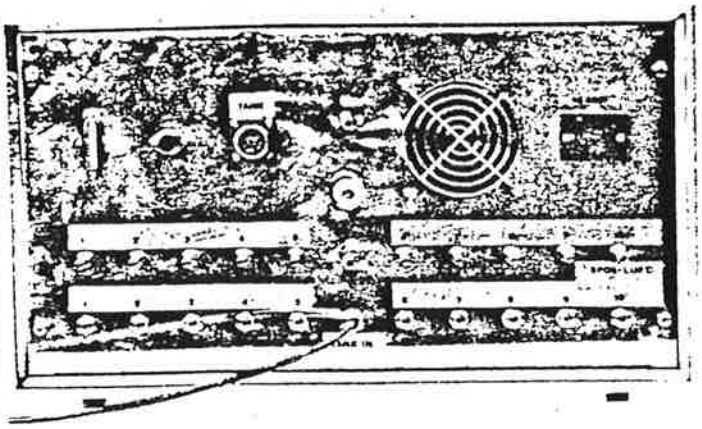

*Figure 4. Injection and sampling unit.*

Two plastic tubes, one for injection and one for sampling, are passed to each room to be monitored. Air in each room is sampled sequentially. The measured tracer gas concentration is used to continuously update the necessary injection rate, to maintain a constant concentration.

The current version of the apparatus maintains a constant concentration of 500 ppm which is too high for use in occupied rooms. It would be difficult to maintain a lower concentration as concentrated tracer gas is injected. Using diluted tracer gas was considered to be too expensive and would reduce the accuracy.

A special mixing fan was developed (see Figure 5). The fan is located on the floor in the middle of the room to be tested. The tracer gas enters below the fan and a gentle air flow will move the tracer gas upwards. The fan is powerful enough to mix the tracer gas, without influencing the air infiltration.

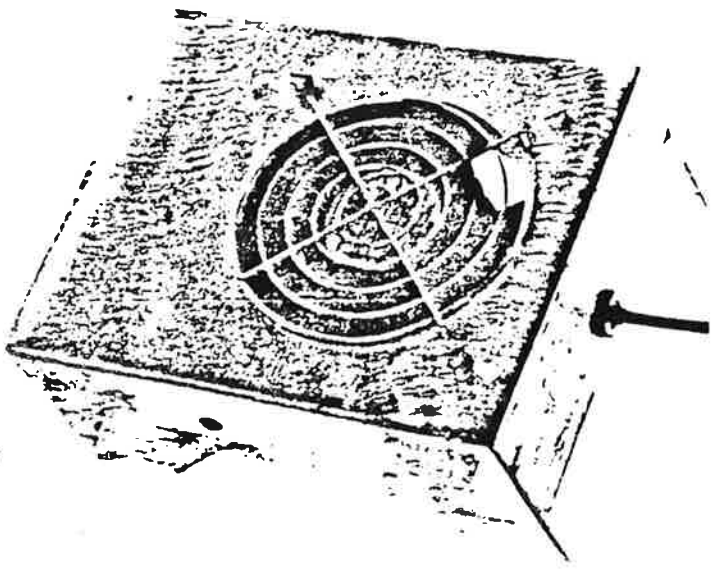

*Figure 5. Special mixing fan.*

A special unit for calibration of the tracer gas flow was developed. The basic principle of the unit is the principle of communicating vessels with liquid. Each plastic tube used for injection is calibrated.

The above described equipment can also be used for air infiltration measurements using a constant tracer gas flow technique or using the decay technique.

## Preliminary Experimental Results

The automated air infiltration measurement system has been used in a couple of houses. In order to see how well the mixing fans work the tracer gas concentration was measured at nine different locations in a room. This was done in a one-family house with natural ventilation. The tracer gas was injected at one location. The concentration increased simultaneously at all nine locations and the target concentration was reached after 45 minutes (see Figure 6).

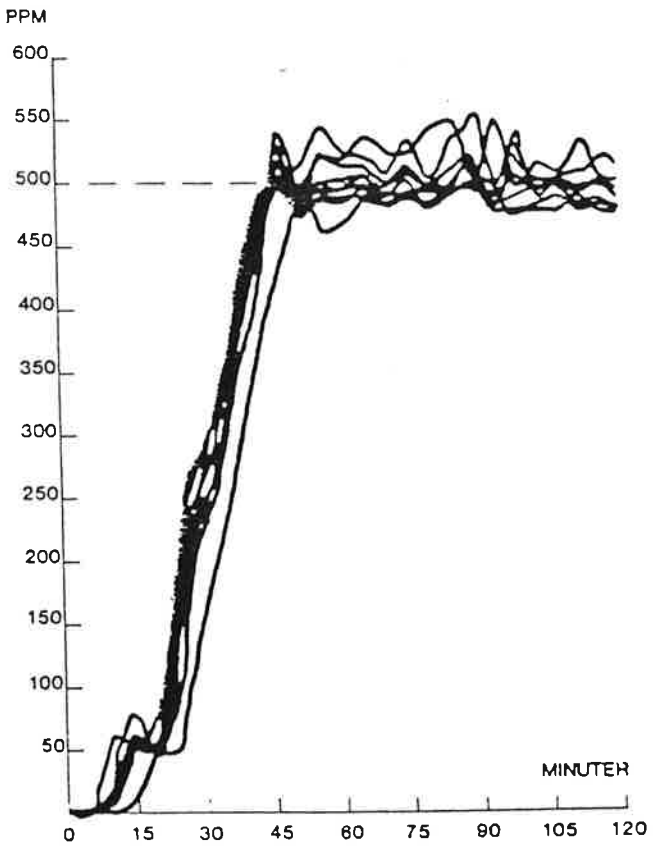


*Figure 6. Concentrations of tracer gas as a function of time at nine different locations.*

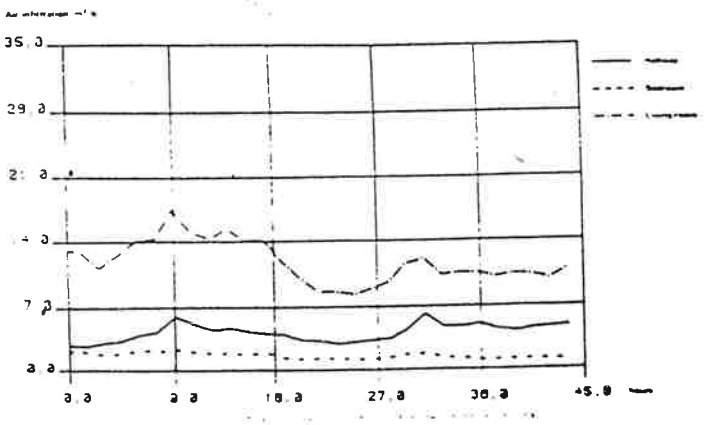

*Figure 7. Air infiltration as a function of time in three rooms.*

For 45 hours tracer gas was injected into each room and the concentration was maintained at a constant level. The ventilation rate changed quite a lot from room to room and with time. One bedroom had hardly any ventilation at all, while the living-room was well ventilated (see Figure 7).

## Conclusions

An automated air infiltration measurement system has been developed with which continuous air infiltration measurements can be made. The supply of fresh air can be monitored simultaneously in nine different rooms. The ventilation rate is given directly in $m^3/hr$. There is no need for any complicated estimation of the effective volume. The system can also be used for constant tracer gas flow measurements and decay measurements.