# 6861



However, they noted that the $CO_2$ sensors responded very well to the number of people in the room, and, in the right circumstances, a $CO_2$ sensor could adequately control the ventilation rates to provide acceptable air quality.

They also concluded that because of the heat load of the lighting, turning off the lights when the room was unoccupied would save a considerable amount of money, due to reduced ventilation as well as the direct savings in powering the lights themselves.

The VOC sensors responded well to pollutant sources in the space, but responded to other things as well, such as relative humidity and changes in the outdoor air quality. The researchers suggested that a system relying on VOC levels would need well-calibrated sensors in both the inlets and outlets, with software to calculate the difference. It is this figure that would regulate the air flow rate.

RH sensors proved themselves to be accurate, but their output increased only slightly for a large number of people, and they reacted to background changes, making them unsuitable for this type of application.

### For More Information

Copies of the report are available for SEK 112 from Svensk Byggtjänst, S-171 88 Solna, Sweden.

# TOOLS AND TECHNIQUES

## Some $CO_2$ Techniques May Not Give Accurate Picture of Ventilation

A study by the US National Institute of Standards and Technology (NIST) indicates that peak carbon dioxide ($CO_2$) calculations and $CO_2$ detector tubes may give drastically inaccurate measures of building ventilation rates.

The study, conducted at the Bonneville Power Administration in Portland, Oregon, USA, by W. Stuart Dols and Andrew K. Persily appears in a new publication from NIST, *A Study of Ventilation Measurement in an Office Building*. The study's purpose was to evaluate several current ventilation measurement techniques, because IAQ practitioners often have to make onsite assessments.

They found that while many of the methods tested showed similar results, others were less reliable. Peak $CO_2$ calculations, for example, overestimated ventilation rates by as much as 100%, while $CO_2$ detection tubes gave imprecise readings, potentially compounding the problem.

### Building Description

The Bonneville Power Authority's administration building is a seven-story office building with a one-story basement. The conditioned space has a floor area of 32,500 square meters, which equates to about 350,000 square feet. The volume is about 114,000 cubic meters including the return air plenum — or about 4,030,000 cubic feet.

A penthouse mechanical room houses the main HVAC systems, consisting of three large variable air volume systems, one serving the center of the building and the others serving the east and west sides.

The building is designed to the ASHRAE 21-1981 ventilation standard, which requires 5 cubic feet per minute (cfm) per person of outdoor air (O/A). This corresponds to about 0.15 air changes per hour (ach). ASHRAE standard 62-1989 calls for 20 cfm/person, which would correspond to about 0.6 ach for this building.

### Measurement Methods

The researchers measured several parameters, using a variety of methods. Among these were:

- Whole building air change rates, using the tracer gas decay method, in which the tracer gas $SF_6$ was injected by an automated system;
- Direct measurement of air flow, using pitot tubes, hot wire anemometer, and vane anemometer;
- Percent of outdoor air, using automatic $SF_6$ injection, automatic $CO_2$, and $CO_2$ detection tubes;
- Ventilation rate per person, using $SF_6$ injection and the peak $CO_2$ calculation; and
- $CO_2$ buildup analysis.

The researchers used the following formula for determining percent of O/A intake:

$$\%OA = \frac{C_{return} - C_{supply}}{C_{return} - C_{outdoor}}$$

where C is the concentration of either tracer gas or $CO_2$.

To determine the ventilation rate per-person they used:

$$Q_p = \frac{G_p}{(C_{eq} - C_o)}$$

where

$Q_p$ is the per-person building ventilation rate in $m^3$ per person,

$G_p$ is the per-person $CO_2$ generation rate,

$C_{eq}$ is the indoor $CO_2$ concentration, and

$C_o$ is the outdoor $CO_2$ concentration.

## Results

The researchers found that the $SF_6$ measurements of whole building air change rates correlated closely with an earlier study of the building done between 1987 and 1989.

In the direct measurement tests, they found that the three methods used were very close — within 10% of one another. In determining the percent of O/A intake, they also found that the $SF_6$ and automatic $CO_2$ methods were in good agreement. However, the $CO_2$ detection tubes led to some discrepancies.

The researchers found that $CO_2$ levels shown on the tubes varied significantly with the person reading the tube. This, they report, is due to the tubes' low resolution, the difficulty in reading them, and calibration errors. For the study, the researchers used three-person readings, but found that some single-person readings gave unreasonable results — less than 0% or more than 100%.

The peak $CO_2$ methods proved to be the most unreliable. Because the equation depends on the building's $CO_2$ being at equilibrium, the method overpredicted $CO_2$ from 50% to 100%. This building, like most office buildings, is occupied by a constant number of people only from 9 a.m. to noon and from 1 p.m. to 5 p.m. Depending on the air changes per hour, it can take anywhere from three to six hours for a building to reach 95% of the steady-state $CO_2$ concentration. Compounding the overprediction is the unreliability of the detector tubes, which could skew the calculations.

The researchers also noted some of the practical considerations, such as the accessibility of ducts for direct readings, that might make one method preferable over another.

## Discussion

An interesting note is the implications of this for the Canadian ventilation study reported in the April 1993 ***IAQU***. In that study, the researchers used the peak $CO_2$ method to estimate the ventilation rate per person and reported ventilation rates ranging from 24 to 84 cfm.

In that study, originally reported in the *New England Journal of Medicine*, the researchers concluded that increasing ventilation rates had no effect on occupants' reports of symptoms consistent with sick building syndrome. One concern with that study is that the ventilation rates reported by the researchers are far above those found in most buildings, and certainly higher than those usually found in "sick" buildings.

If the NIST study is correct, the Canadian study's ventilation results could have been overestimated by between 50% and 100%, calling into question any conclusions based on the data.

In reporting the Canadian research, ***IAQU*** noted a discrepancy between the increases in outdoor air and the increases in percent of outdoor air in total supply. This overestimation may account for the discrepancy.

## For More Information

For more information on the study, contact the US Department of Commerce, National Institute of Standards and Technology, Building and Fire Research Laboratory, Gaithersburg, MD 20899, USA; (301) 975-2000.

Copies of the complete study, *A Study of Ventilation Measurement in an Office Building*, are available for purchase for US $25 from Cutter Information Corp., 37 Broadway, Arlington, MA 02174, USA. Call Karen Kurr, (617) 641-5118 or (800) 964-5118, Fax: (617) 649-1950 or (800) 888-1816.