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From Our Readers

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From Our Readers

To the Editor:

The subject of this letter is information that we have developed on the use of the Gastech Model RI-411, Infrared CO_2 Indicator during evaluations of indoor air quality.

Section 0.7 of the Instruction Manual states, "If the instrument is taken into a high-CO_2 area, the ambient atmosphere will gradually diffuse into the optical path . . ., and tend to cancel the reading from the sample. . ." The purpose of this letter is to indicate: (1) the approximate time constant and magnitude of this effect; (2) two possible fixes, neither of which is completely satisfactory.

The National Institute for Occupational Safety and Health (NIOSH) receives many requests for Health Hazard Evaluations of office buildings (sick building syndrome). For these evaluations, CO_2 measurements are often useful as an indicator of poor ventilation practices. If there are reported health problems and CO_2 levels are "high" (greater than 1000 ppm), there is a high probability that increasing the air exchange rate in the affected area of the building will help alleviate the problem. The Gastech model RI-411 Infrared CO_2 Indicator appeared to be an instrument which could make real-time measurements. The Model RI-411 is a light-weight, battery-operated instrument which utilizes a double beam infrared detection system to measure CO_2 concentrations in the range of interest (300–2000 ppm). However, an apparent drift of the instrument during use led industrial hygienists to question the accuracy of the data.

An evaluation of the instrument showed that the anomaly of the instrument is the large "dead air" space between the infrared source and the active/reference cell. If the concentration of CO_2 in this space changes during a measurement, the instrument reading will change. This space is not well sealed, and room air is constantly diffusing into the space. The changes in instrument reading as air diffuses into the space can be dramatic.

While it is intuitively obvious that a reference cell will cancel out effects that are "seen" equally by both the reference and sample cell, it is also not always true. Figure 1 gives a theoretical explanation of why it is not true. Basically, the amount of light transmitted is a log function of the concentration "c." Thus, the instrument should find the ratio I_r/I_s, not the difference $(I_r - I_s)$. If this was an ideal instrument, the numbers in the "$(I_r - I_s)$" column of the "Use (start)" and "Use (later)" rows would be identical.

Figure 2 shows what happened for an extreme change in the atmosphere surrounding the cell. For this test, the instrument was calibrated with normal room air surrounding the cell. Then, at time zero, the instrument was placed in a chamber containing 50,000 ppm CO_2. However, the sampling probe was left to draw from the normal room air. Thus, the reading should have been a reasonably constant room air concentration. As Figure 2 shows, in 4 minutes the reading dropped to zero. At t = 4 minutes, the instrument was placed in room air and the reading eventually returned to the original value.

Figure 3 shows the results of a similar test, but the change in the environment of the cell was much less extreme. Here again the instrument was calibrated with the cell surrounded with room air. At time zero, it was placed in a chamber containing zero air. Since the probe was still sampling room air, the reading should have remained constant. At the 35-minute mark, the instrument was returned to room air and the reading essentially returned to its original value.

If the instrument is moved from one area

The instrument is zeroed and spanned outdoors where the CO2 concentration in the dead air space is 300 ppm. It is then used indoors where the concentration is 800 ppm. Zero gas is 0 ppm. Span gas is 800 ppm. When the instrument is brought in to measure indoor air, the concentration in the dead air space gradually changes from 300 ppm to 800 ppm during the monitoring period. What is the effect on (Ir - Is) reaching the detector?

A = abc BEER'S LAW
- A - light absorbed
- a - gas/cell constant
- b - path length
- c - concentration

A = log(1/T)
- T - light transmitted %

T = Iout/Iin
- I - light intensity

$$I_{out} = I_{in} \cdot 10^{-abc}$$

As an example of the calculations, assume:
1. ab of the dead air space equal 0.0005
2. ab of the sample and reference cells equals 0.001 (path length is longer)
3. Ix = Iy since air is uniform in the dead air space
4. c = 0 in the reference cell

Instrument Function	Ix or Iy	Is	Ir	(Ir - Is)
Zero	0.71 Io	0.71 Io	0.71 Io	0.00 Io
Span	0.71 Io	0.11 Io	0.71 Io	0.60 Io
Use (start)	0.71 Io	0.11 Io	0.71 Io	0.60 Io
Use (later)	0.40 Io	0.06 Io	0.40 Io	0.34 Io

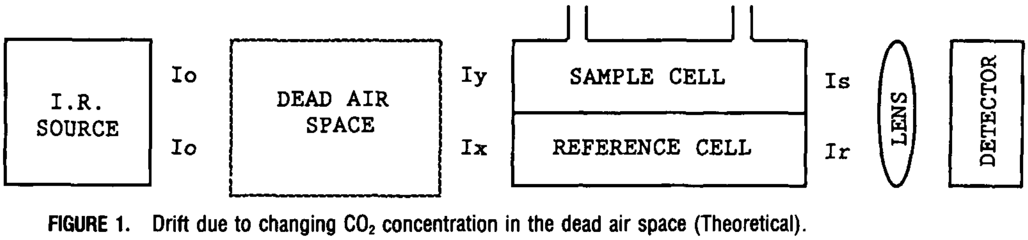

FIGURE 1. Drift due to changing CO_2 concentration in the dead air space (Theoretical).

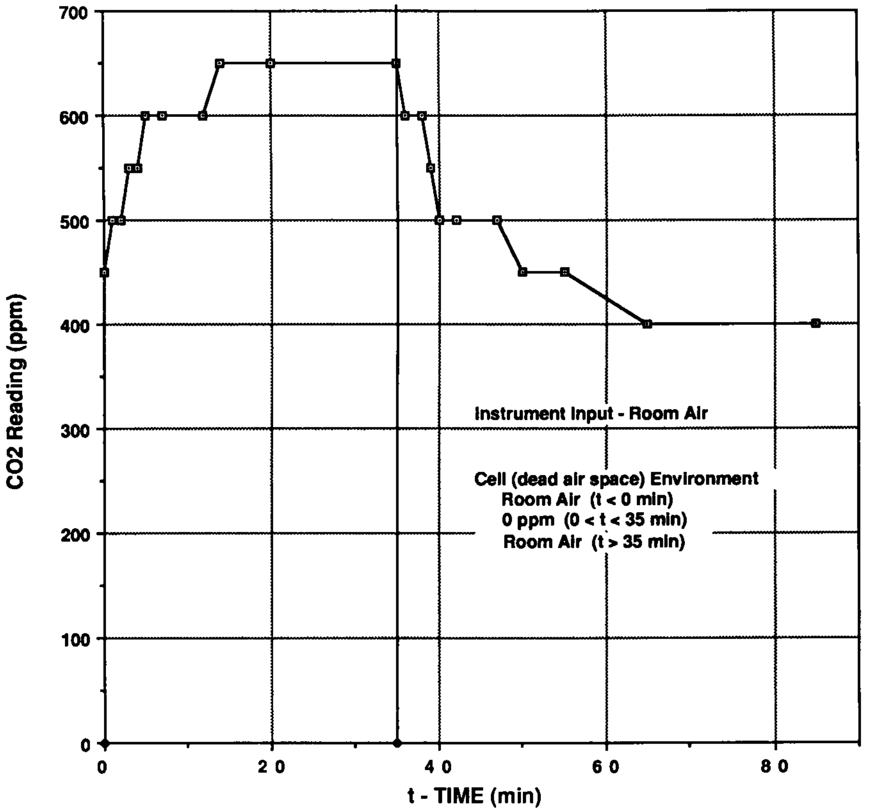

FIGURE 2. Response to large changes in CO_2 concentration around dead air space.

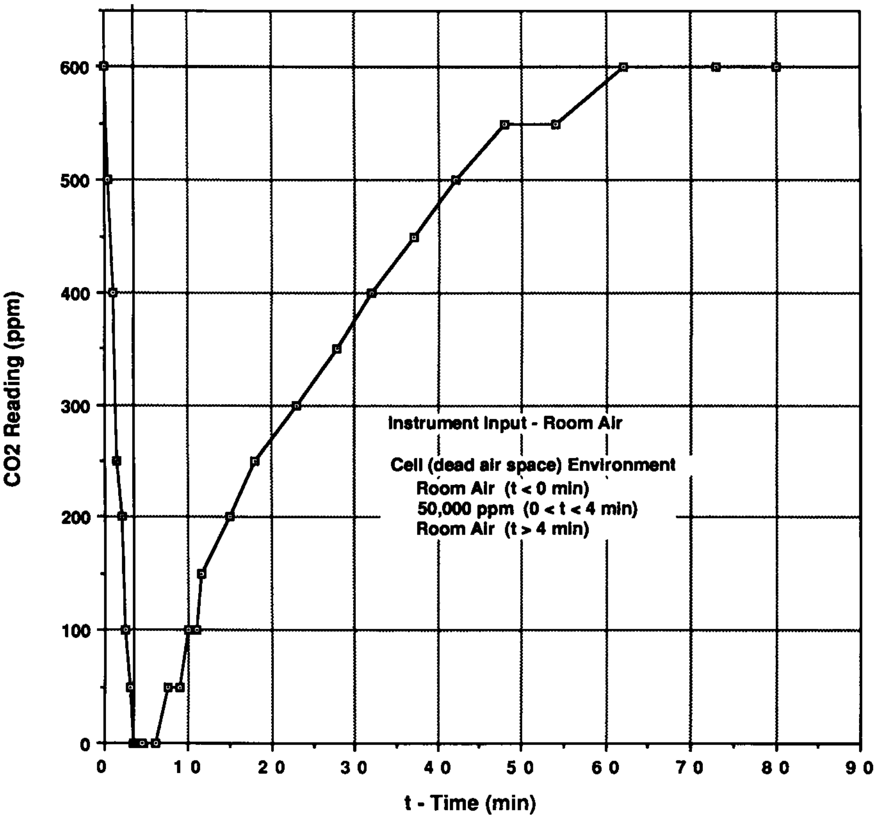

FIGURE 3. Response to small changes in CO_2 concentration around dead air space.

TABLE I. Readings obtained

	1960 ppm Reads	Percent Error	Room Reads
With Scrubber	1450	26	450
Without Scrubber	1150	41	550
With Scrubber	1500	23	500
Without Scrubber	1100	44	500
With Scrubber	1500	23	450
With Scrubber	1550	21	500

to another to measure CO_2 levels, the user should interpret the data obtained with caution. Figure 3 shows what is likely to happen if the instrument is calibrated at one set of conditions, and then used in an environment which is different by 450 ppm. The initial reading will be correct, but then it can be expected to change by about 200 ppm. This change will occur over a 10- to 15-minute period. Similar errors can be expected for other changes in the instrument environment. It is our understanding that Gastech is no longer recommending this instrument (in its current configuration) for use in indoor air quality investigations [personal communication with Ken McDermith, 10/87].

Existing model RI-411 instruments need a simple fix to allow them to be used for industrial hygiene surveys. Two possible fixes were tested: 1) pump zero air into the dead air space (chopper chamber); 2) pump sample air into the dead air space. Gastech modified one of the instruments (putting a hole in one of the screws in the side of the chopper chamber) to allow these tests. A small portion of the air that went through the sample cell was routed to the dead air space (either directly or through an Ascarite® zero filter).

Using zero air, the instrument was zeroed with the "AIR CAL" control. Using 800 ppm span gas, it was then spanned using the "SPAN" control. After rechecking zero and span again, it was connected to a bag containing 1960 ppm CO_2 (concentration verified with a Gastech model 3252 which was zeroed and spanned with the same zero filter and 800 ppm gas) in air and both this reading and one of room air was taken. Room air numbers were taken to see if they appeared "reasonable."

Table 1 shows the readings that were obtained. When the zero filter is used (on air pumped into the dead air space), the Gastech meter reads about 23 percent lower than it should. If no filter is used (on air pumped into the dead air space) the meter reads about 42 percent low. It is apparent that neither fix is satisfactory. However, either fix will improve precision, and if a calibration curve is used, accuracy.

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To the Editor:

Regarding the letter from Messrs. Huebener and Gorman of NIOSH concerning our Model RI-411 CO_2 indicator:

We, of course, are aware of the limitation of this unit as outlined in their report, as witnessed by the warning in the instruction manual. Because of this limitation, we have not advertised or endorsed the RI-411 for applications such as "sick building syndrome" monitoring. We have other monitors in our line that are suitable for that use and have also pursued remedies for the RI-411, including approaches similar to those outlined in the report.

A recent development, which I have discussed with Mr. Gorman, is a new optical bench using a single-beam cell that does not suffer from the anomaly described in the report, namely intrusion of the atmosphere being tested into the optical path external to the measurement and reference cells. In fact, NIOSH is in the process of sending back their units to be converted to the new style bench, and we invite other owners of the RI-411 to contact us if they are using the instrument in an application where they are concerned about this effect. If the RI-411 is used to check vessels or areas where the instrument is kept outside the area to be tested (e.g., a vessel entry test), the problem described in the report does not manifest itself.

Regarding evaluations of "sick building syndrome," we would also be delighted to discuss an instrument we have designed specifically for that application, our Model 4776. This model uses a patented diffusion-sampling single-beam infrared detector, and includes a built-in chart recorder or datalogger.

Thank you very much for the opportunity to respond. As I mentioned, we welcome calls from users of the RI-411 to discuss this phenomenon. They can call me personally at (415) 794-6200.

Bruce Holcom
Assistant Sales Manager
GASTECH, INC.

To the Editor:

This is a short note from the land of the Kiwi to tell you how much we appreciate *Applied Industrial Hygiene.*

We find it to be the most relevant journal available in Industrial Hygiene, in comparison with the material in others, of which only ten percent is relevant. This, you will realise, is a surprising result in a nation not recognised for its industrial might, as your own! Obviously, the editorial policies are well tuned to the needs of readers.

We especially enjoy the articles on the philosophy of Industrial Hygiene—they "keep us honest"—and such interesting snippets as the account of sodium chloride labelling!

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To the Editor:

The AEC Industrial Hygiene Fellowships described by Dr. Donald Ross during the period 1955–65 were also influenced by the increasing requirements for trained engineers and scientists in the new and expanding field of air pollution control. As a participant on the faculty and in research at one of the universities of the period, my perspective was that there were greater numbers of industrial hygienists being trained in the growing field of air pollution as a branch of industrial hygiene.

The Public Health Service provided air pollution training grant support for fellowships and teaching, as well as active research grant support to many universities during this period. Many faculty and research staff worked in both areas simultaneously at many schools. (See, for example, the Proceedings of the AEC Air and Gas Cleaning Conferences 1951, etc.)

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