



Direct-Read Monitoring System for Carbon Monoxide

By: G. M. Mihaylov, K. S. Kirolos and A. E. Rice, K&M Environmental, Inc.

Introduction

Carbon monoxide (CO) is one of the most widespread air pollutants. It is the only common industrial gas that is both highly toxic and odorless. A number of devices for monitoring and directly estimating CO concentrations have been introduced for a wide range of applications. However, most of the available devices show poor metrological properties. An ideal CO monitor should have short response time and direct-read capability; it should also meet the accuracy and precision standards set by the Occupational Safety and Health Administration (OSHA). The goal of this work was to develop a direct-read simple CO monitoring system to provide reliable results in a wide range of environments.

The monitoring system consists of a badge-like monitor and a color comparator. The monitor operates on the principle of passive diffusion. It is constructed from six cells that change color at certain levels of exposure to CO. A color comparator is used in conjunction with the monitor to increase the resolution and accuracy of measurement.

The sensor is constructed from a uniformly coated indicator layer on an inert, transparent surface. The chemical reaction between CO and the sensor is based on a modified palladium color chemistry. The nature of the design allows a constant diffusion path of 2 mm which results in a fast response of only 2 seconds.

The monitor is designed to react selectively with carbon monoxide with minimum interference from other substances. Up to 1 TWA ammonia shows no interference. Hydrogen sulfide reacts with similar sensitivity. High concentrations of acetylene and ethylene lead to positive bias.

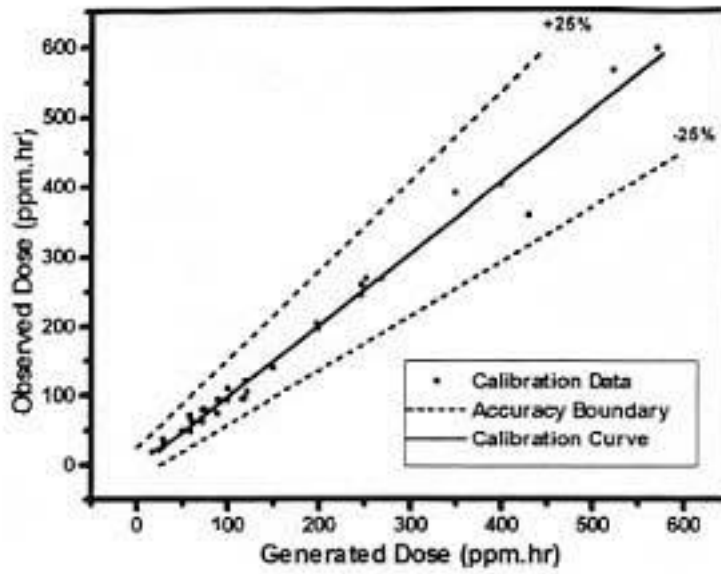
To validate and assess the performance of the monitor, a protocol based on the Protocol for Passive Monitors recommended by the national institute of Occupational Safety and Health (NIOSH) was used.

Experimental Conditions

Calibration (Figure 1)

- Includes all data points generated from exposing the badges to different environmental conditions.
- Six badges were used in each experiment
- Five observers determined the exposure dose for each experiment.

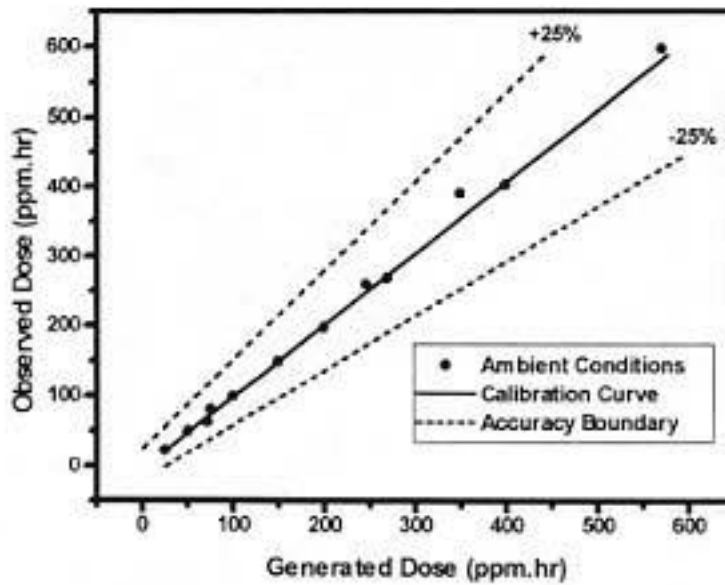
Figure 1: Calibration Data



Ambient Conditions (Figure 2)

Face Velocity	9 - 11 cm/sec
Temperature	19 - 27°C
Relative Humidity	45 - 65%

Figure 2: Ambient Conditions



Interchangeability (Figures 3 and 4)

Concentration	0.1 - 5.7 TWA
Exposure Time	15 minutes to 63 hours

Figure 3: Interchangeability Effect - Low Concentration

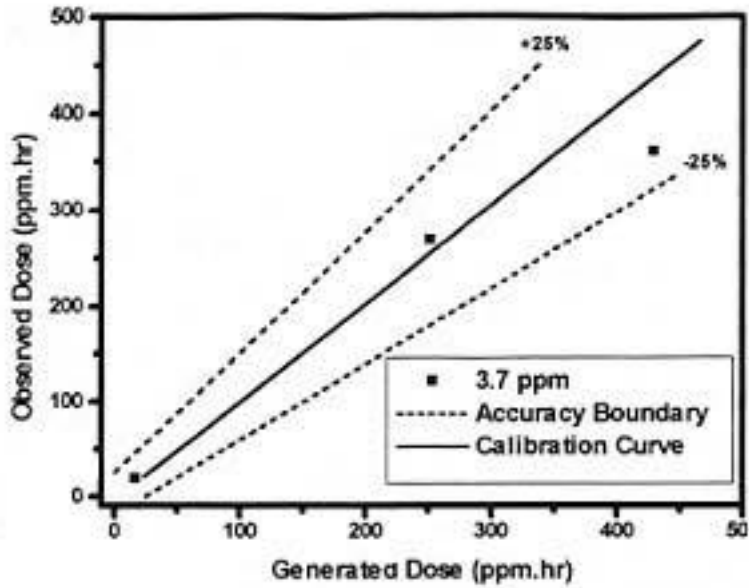
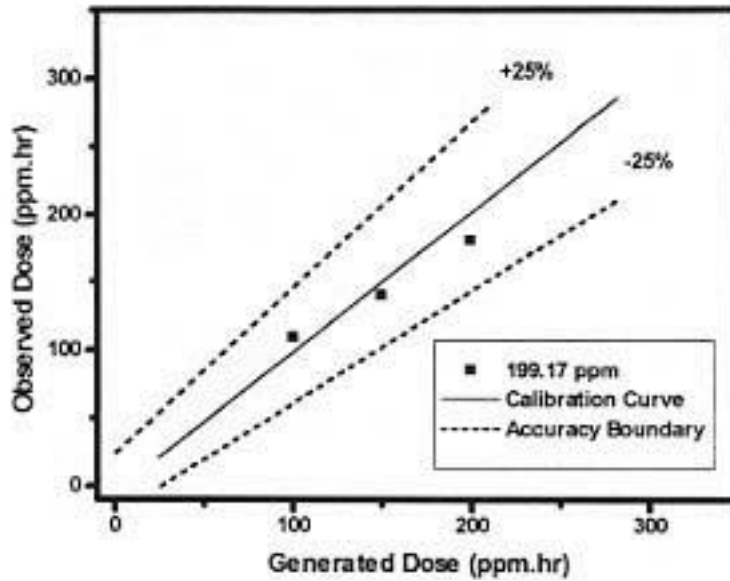


Figure 4: Interchangeability Effect - High Concentration



Face Velocity Effect (Figures 5 and 6)

- 60 cm/sec
- 150 cm/sec

Figure 5: Face Velocity Effect

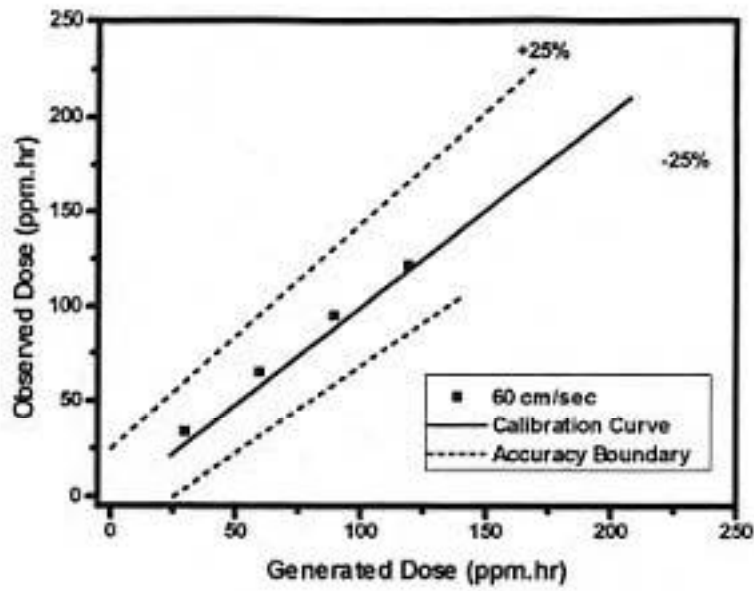
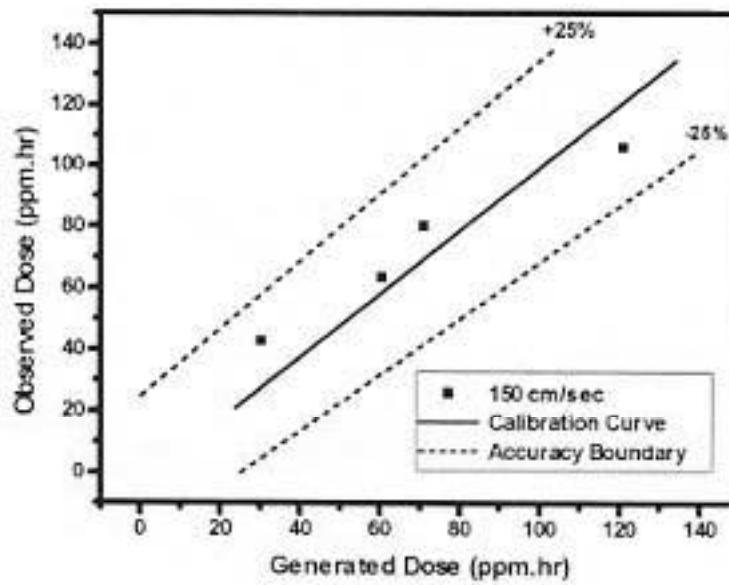


Figure 6: Face Velocity Effect



Temperature Effect (Figures 7 and 8)

- Low Temperature 13°C
- High Temperature 35°C

Figure 7: Low Temperature Effect

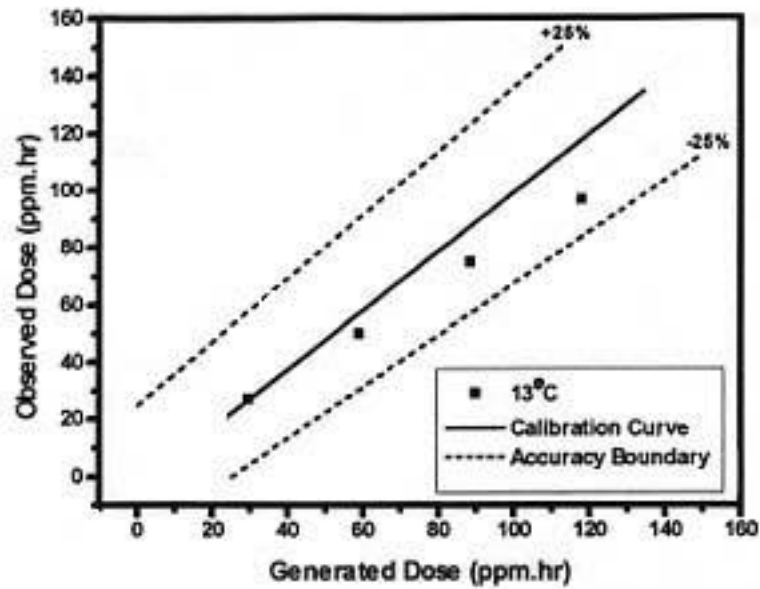
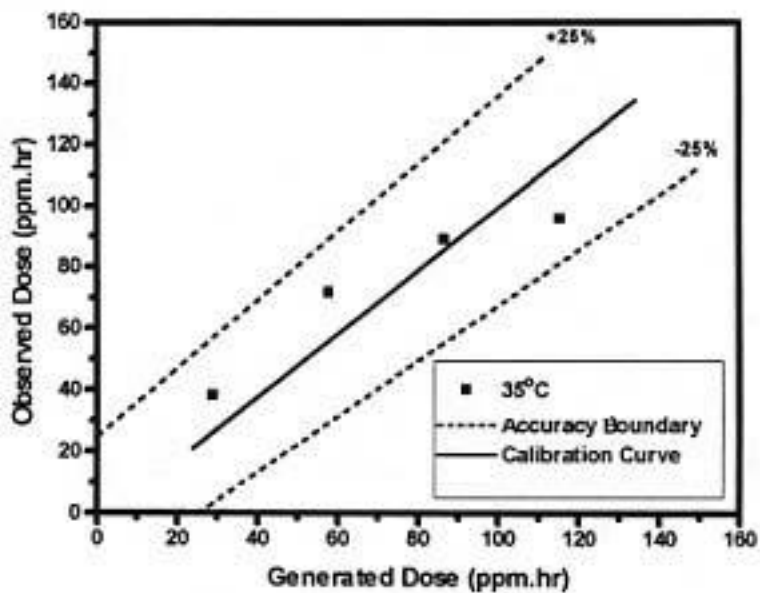


Figure 8: High Temperature Effect



Relative Humidity Effect (Figures 9 and 10)

- 40% RH
- 85% RH

The results presented on the calibration curve (n= 1381) showed:

- Mean CV 7.6
- Mean Bias 0.749
- Overall Accuracy $2CV + |b|$ 15.96

Figure 9: Low Humidity Effect

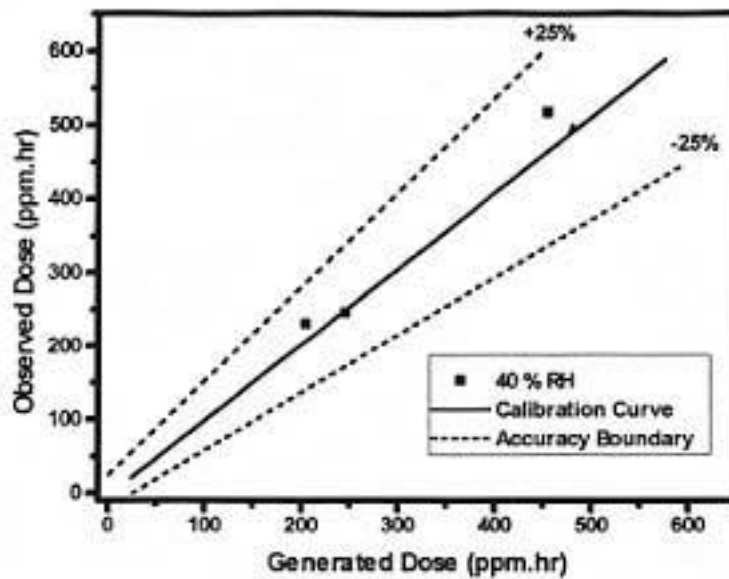
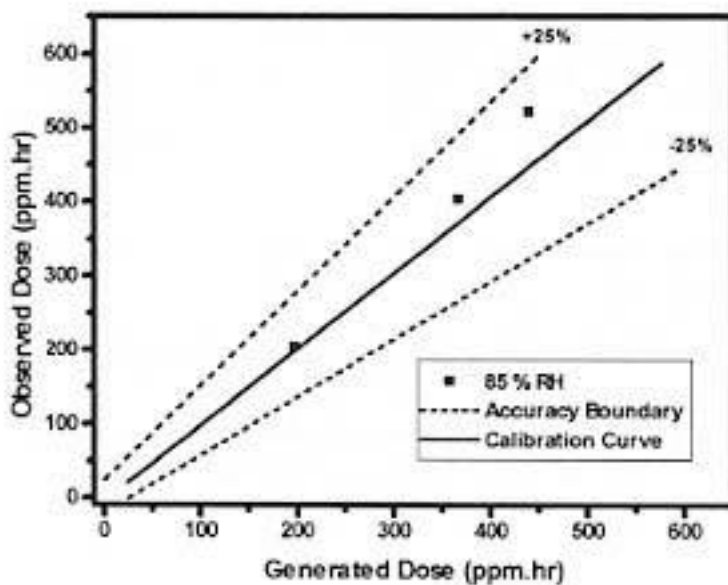


Figure 10: High Humidity Effect



Conclusion

- The ChromAir carbon monoxide system was tested under a wide range of environmental parameters set by OSHA and ACGIH.
- Results at ambient conditions showed an overall accuracy of $\pm 13.69\%$. All results, including those at extreme conditions, showed an overall accuracy of $\pm 15.96\%$, which exceeds OSHA requirements.
- The badge has free mutual exchange between carbon monoxide concentrations and sampling time, i.e. no measurable interchangeability effect.
- No measurable air velocity effect was observed.
- Exposing the badge to low temperature, 13°C , showed a bias of -12.45% . Exposing the badge to high temperature, 35°C , showed a bias of $+6.69\%$.
- High humidity (RH = 85%) showed a bias of $+17.1\%$.
- The CO badge with the comparator is a prominent alternative to personnel and area monitoring within the parameters tested. The badge is good for TWA and 15 minute (STEL) monitor-

ing in the range of 2.5 - 630 ppmxhr (0.008 - 2.25 times TWA).

Acknowledgments

K&M Environmental and the authors gratefully acknowledge the efforts and dedications of Bryan Nurney, Peter DiNardo and Emily McClaugherty for accomplishing this work.