Direct-Read Monitoring System for Carbon Monoxide

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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.

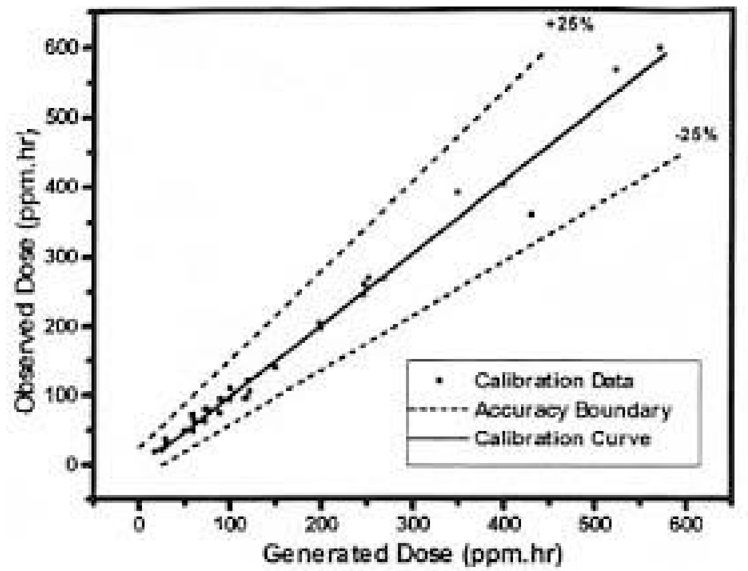
The monitor is designed to react selectively with carbon monoxide with minimum interference from other substances. Up to 1 TWA ammonia shows no interference. Hydrogen sulfide reacts with similar sensitivity. High concentrations of acetylene and ethylene lead to positive bias.
To validate and assess the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

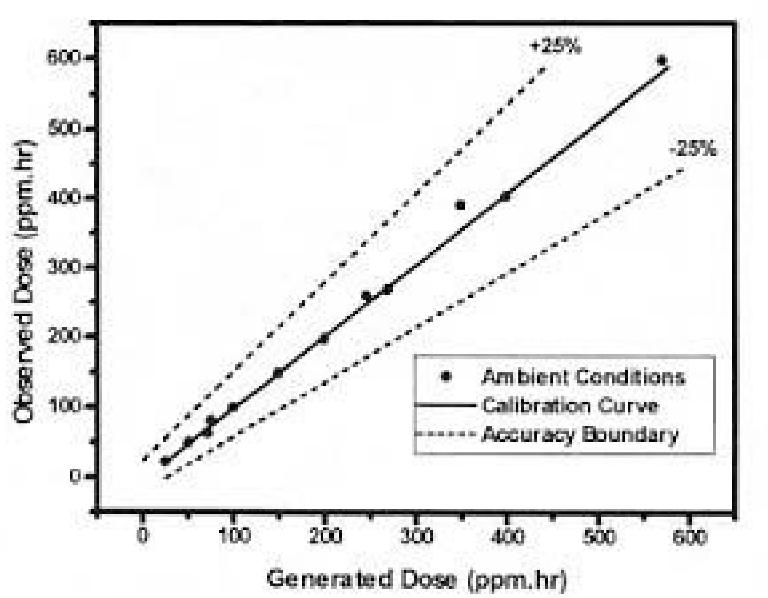
Figure 1: Calibration Data



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

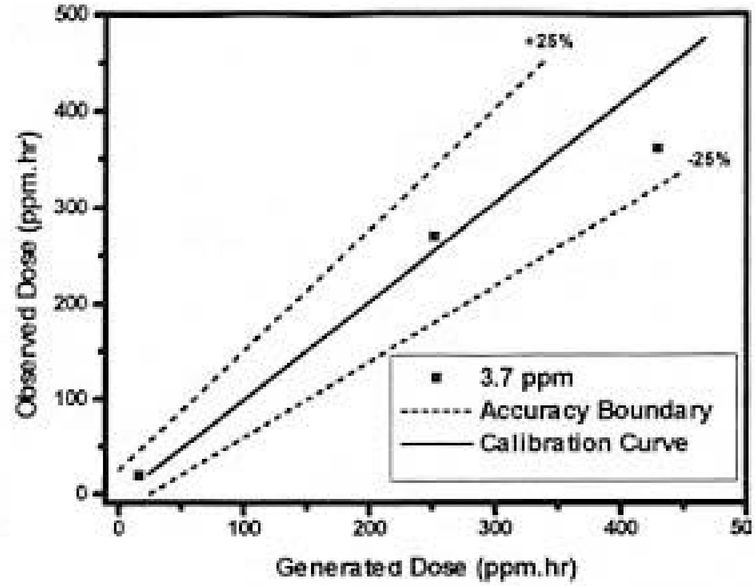
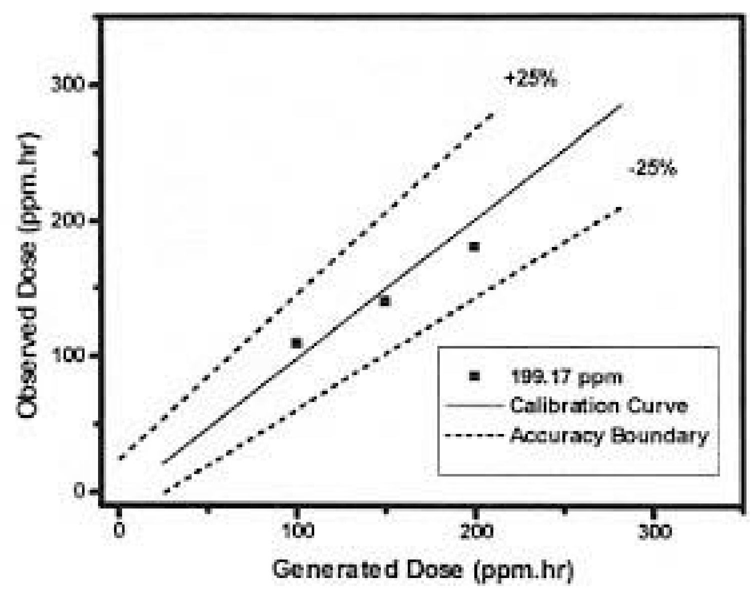


Figure 4: Interchangeability Effect - High Concentration



Face Velocity Effect (Figures 5 and 6)

•60 cm/sec

•150 cm/sec

Figure 5: Face Velocity Effect

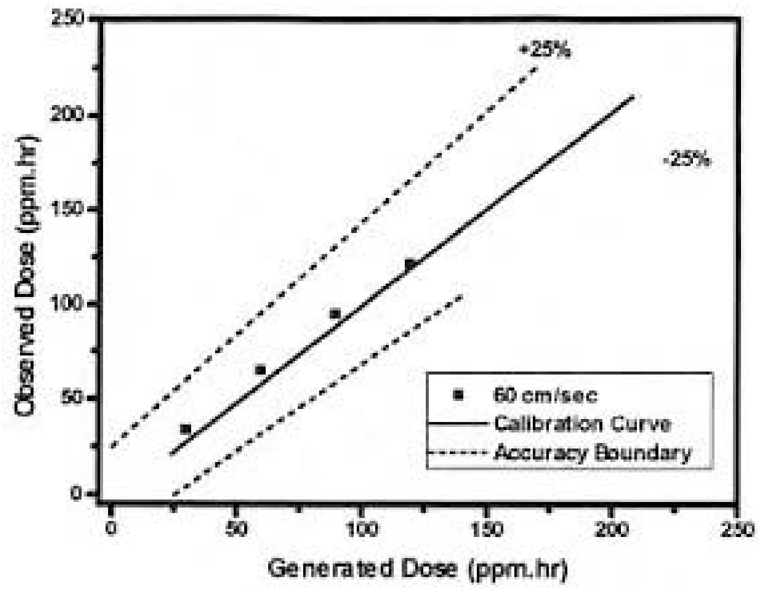
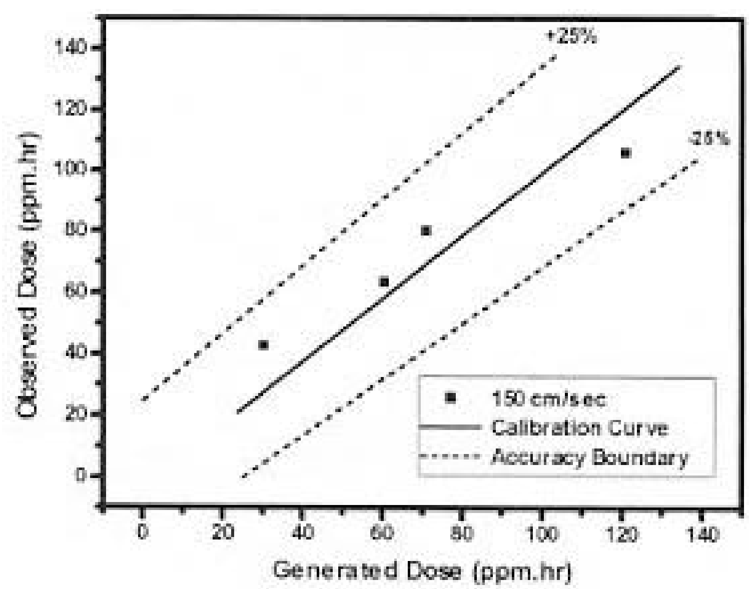


Figure 6: Face Velocity Effect



Temperature Effect (Figures 7 and 8)

- **Low Temperature 13°C**
- **High Temperature35°C**

Figure 7: Low Temperature Effect

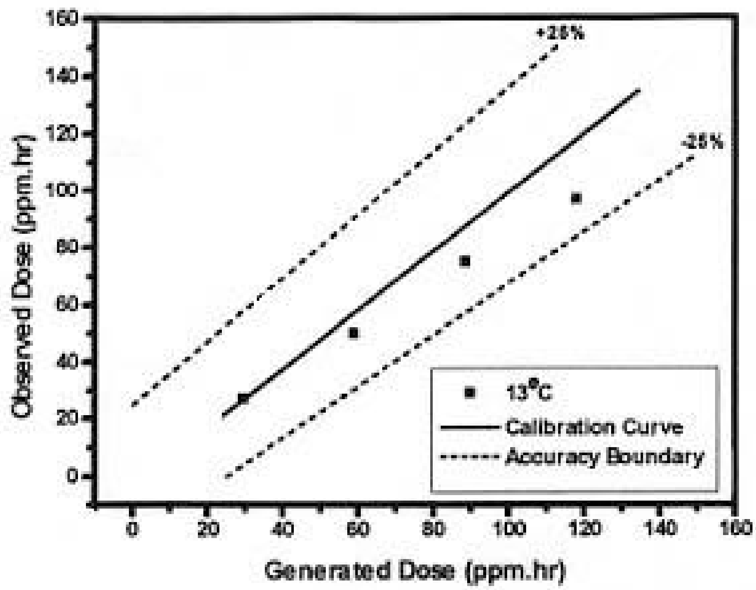
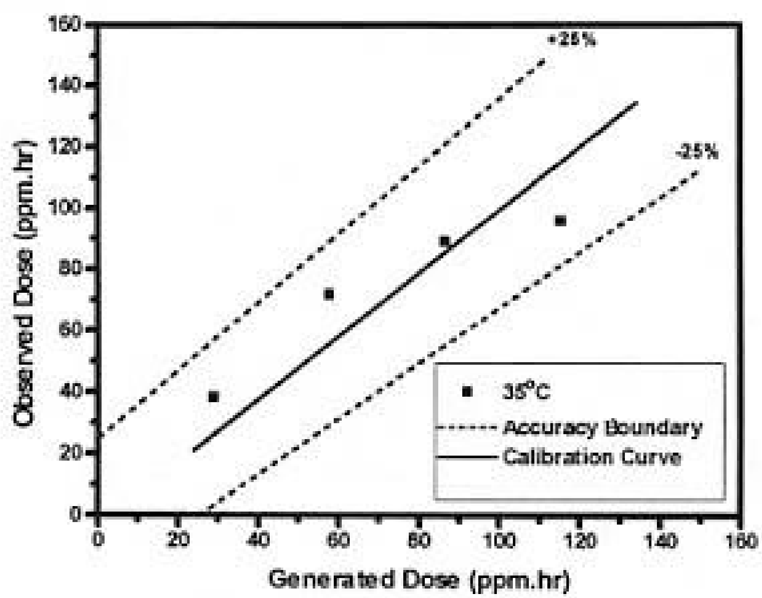


Figure 8: High Temperature Effect



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 + lbl
	15.96

Figure 9: Low Humidity Effect

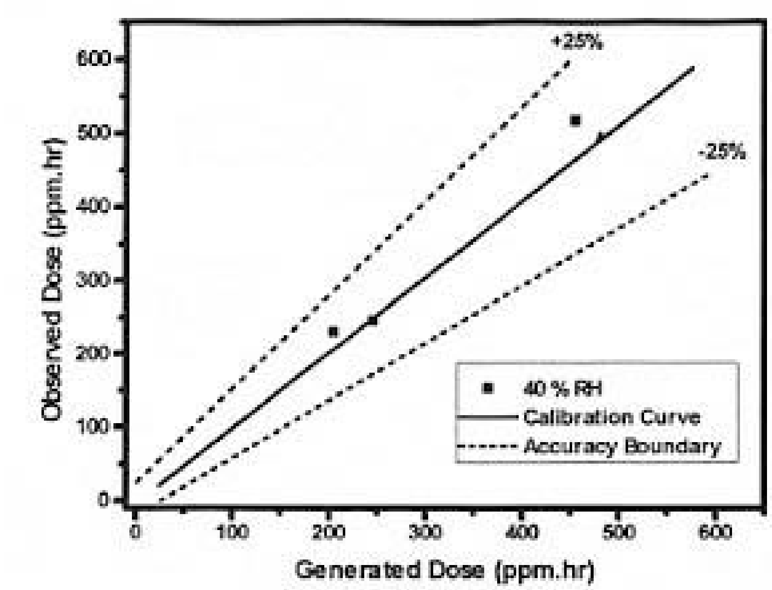
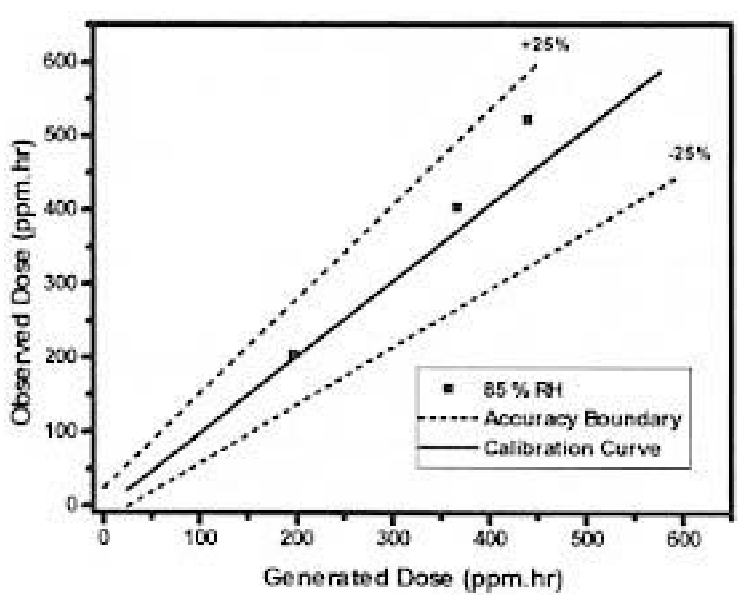


Figure 10: High Humidity Effect



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 ±13.69%. All results, including those at extreme conditions, showed an overall accuracy of ±15.96%, which exceeds OSHA requirements.
•The badge has free mutual exchange between carbon monoxide concentrations and sam pling 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 monitor ing 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).

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