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LOG OF MEETING

Meeting with: Michael G. Apte
Lawrence Berkeley National Laboratory
University of California
Berkeley, California

Meeting Date: January 28, 1997

Location: CPSC, East West Towers, Bethesda, MD

Log Entry Source: Elizabeth W. Leland, EC

Attendees:

Commission Staff

Michael Babich, EHHE
Sandy Inkster, EHHE
Elizabeth W. Leland, EC
Marcia Robins, EC
Don Switzer, ESEE
Sharon White, ESHF

Non-Commission Attendees

Irwin Billick, WEC Consulting, Inc.
Michael G. Apte. Lawrence Berkeley Laboratory
Lara A. Gundel, Lawrence Berkeley laboratory

Subject: Development and Commercialization of a Carbon Monoxide Occupational Dosimeter

Summary:

Mr. Apte requested the meeting. Mr. Apte presented information based on research done by the Lawrence Berkeley National Laboratory and Quantum Group, Inc. to develop a device for measuring carbon monoxide (CO) in CO exposure studies. The primary result of their research was the development of a dosimeter, easily worn by a person on the lapel of one's jacket or shirt, which measures the CO to which the person is/has been exposed. Mr. Apte presented the results of actual field studies undertaken at the Moscone Convention Center in California. The dosimeter, according to Mr. Apte, has been validated in laboratory studies and field tests and is now ready for commercialization.

The results of the laboratory and field studies, as well as the accomplishments of the research, are outlined in copies of the overhead slides used by Mr. Apte in his presentation (attached).

Development and Commercialization of a Carbon Monoxide Occupational Dosimeter

Michael G. Apte, Gregory W. Traynor and Lara A. Gundel
Lawrence Berkeley National Laboratory
University of California, Berkeley, CA

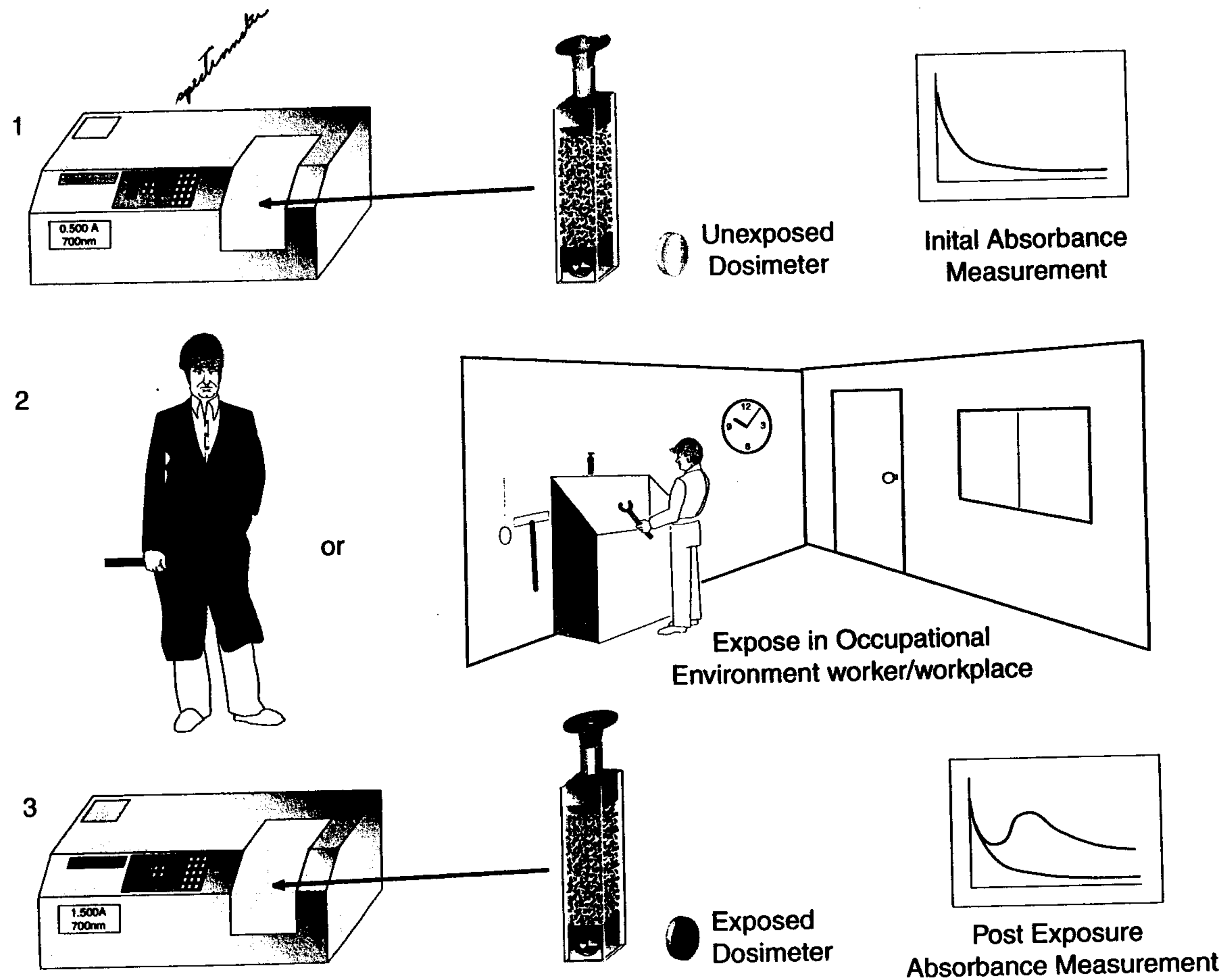
and

Mark K. Goldstein, William B. Helfman and Michelle Oum
Quantum Group, Inc.
San Diego, CA

Goal:

Develop Occupational Dosimeter for CO

- Fully functional 8-hour dosimeter
- Validated in laboratory studies
- Validated in field tests
- Ready for commercialization



1
spectrometer
0.500 A
700nm
Unexposed
Dosimeter
Inital Absorbance
Measurement
2
or
Expose in Occupational
Environment worker/workplace
3
1.500A
700nm
Exposed
Dosimeter
Post Exposure
Absorbance Measurement

Overview

Background

Significance

Video

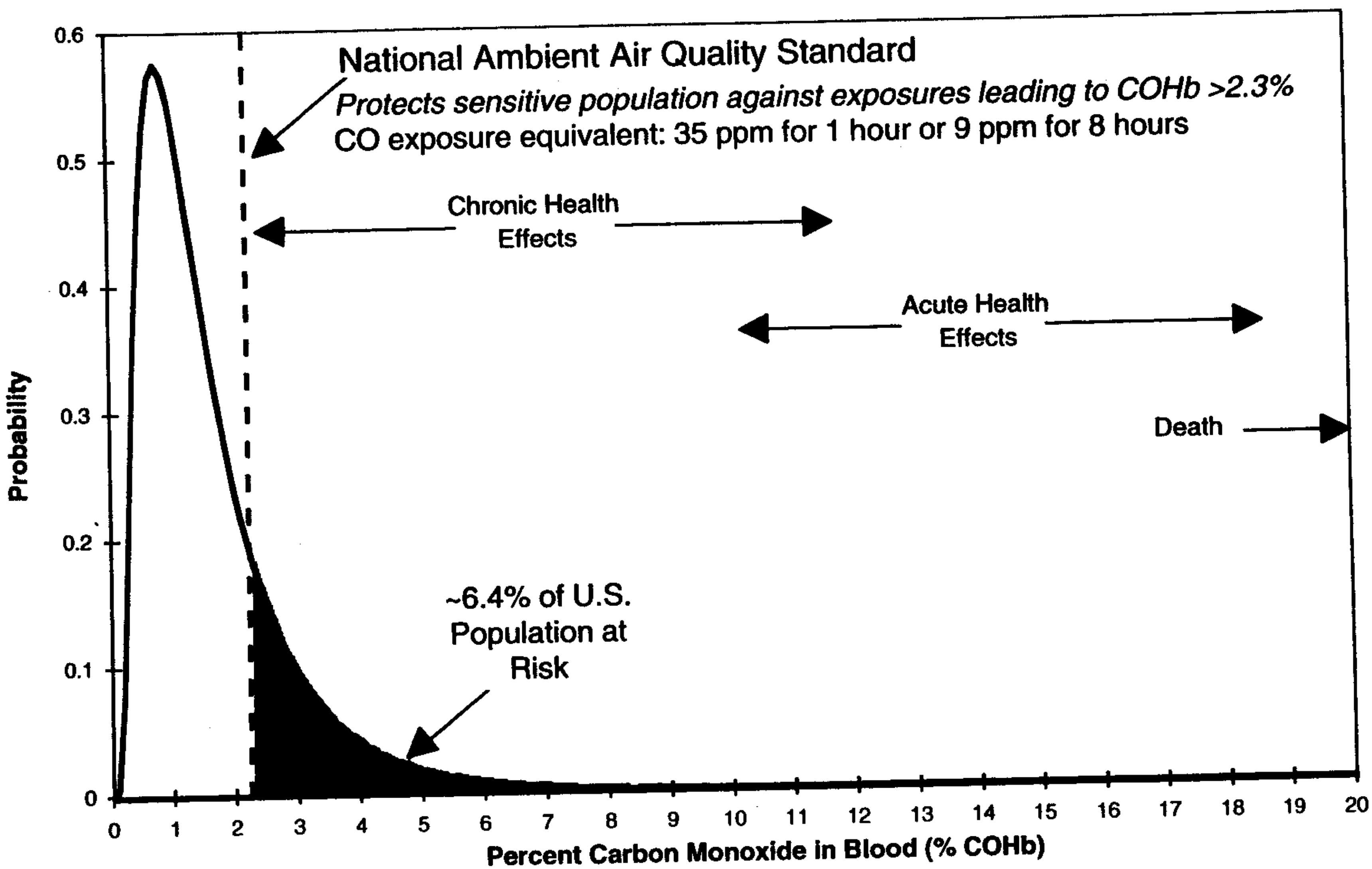
Key accomplishments

Laboratory and field research results

Project management

Summary

Estimated U.S. CO Exposure Distribution



Sources: Data adapted from Radford and Drizd (1982)
USEPA (1991)

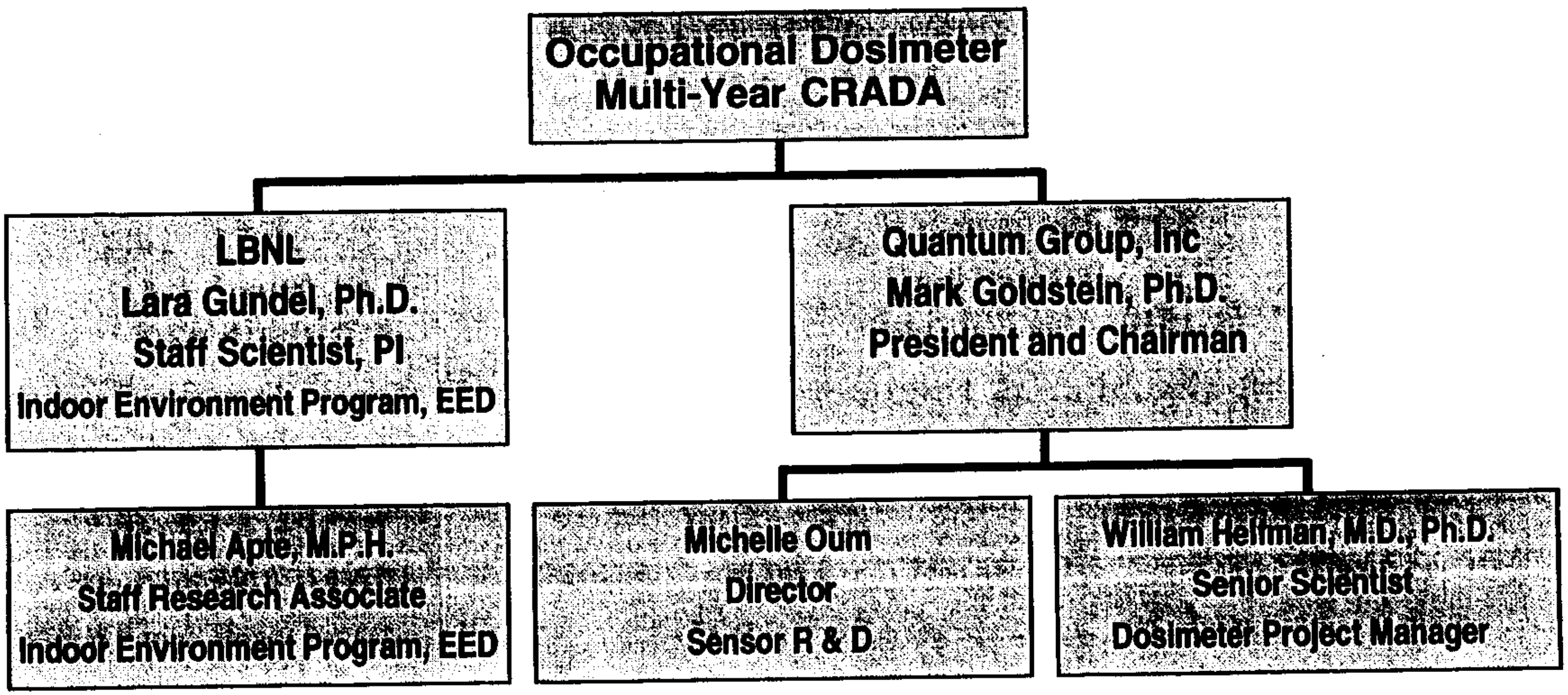
Scientific and Technical Significance

- Accidental CO poisoning kills >1000 people a year in the US. Lifetime death risk is 1 in 4000.
- 13,000 Sub-lethal doses harm the cardiovascular and central nervous systems.
- Lack of suitable instrumentation exposure assessment
- CO dosimeter is <u>essential</u> for population-based measurements of the distribution of exposure.

Methods for Population-Based Studies of Indoor CO Distributions

- Real-time instrumentation - expensive
- Stain tubes ("Dräger" tubes) - inaccurate
- Integrating bag samplers - "the gold standard" but impractical for large studies
- Examples: NO_2 and radon passive samplers have added substantial data on exposure; <u>not available for CO.</u>

Project Team



Project Objectives

- Design LBNL prototype dosimeters using QGI sensors;
- Investigate combinations of sensor types and passive sampler geometries;
- Perform laboratory and field tests of the final design;
- Validate using NIOSH protocols; and
- Compare dosimeter to other CO methods in workplaces.

KEY ACCOMPLISHMENTS	KEY CONTRIBUTIONS LBNL	 UCI
Prototypes	CO passive sampler concept	Develop sensor from literature
Proof of concept	Preliminary field tests	Supply sensors
Compatible materials	Characterize sensor performance	Modify sensor formulation
Control reversibility	Effects of Cu and H_2O	Cu chelation
Control response	Sensor conditioning	Production control
Dosimeter	Design and specifications	Engineer for production
Performance Validation	Lab and field studies	Portable disk reader
Four publications + ⇒	Five inventions	Two patents

Target Specifications

	Occupational Dosimeter	Residential Sampler
Range	10-800 ppm-hour	1-100 ppm-week
Accuracy	$\pm$ 20%	$\pm$ 20%
Precision	$\pm$ 10 ppm-hour	$\pm$ 1 ppm-week

Further Technical Requirements

- Irreversible in operation or storage
- Calibrated for a wide humidity range
- Low sensor-to-sensor variation

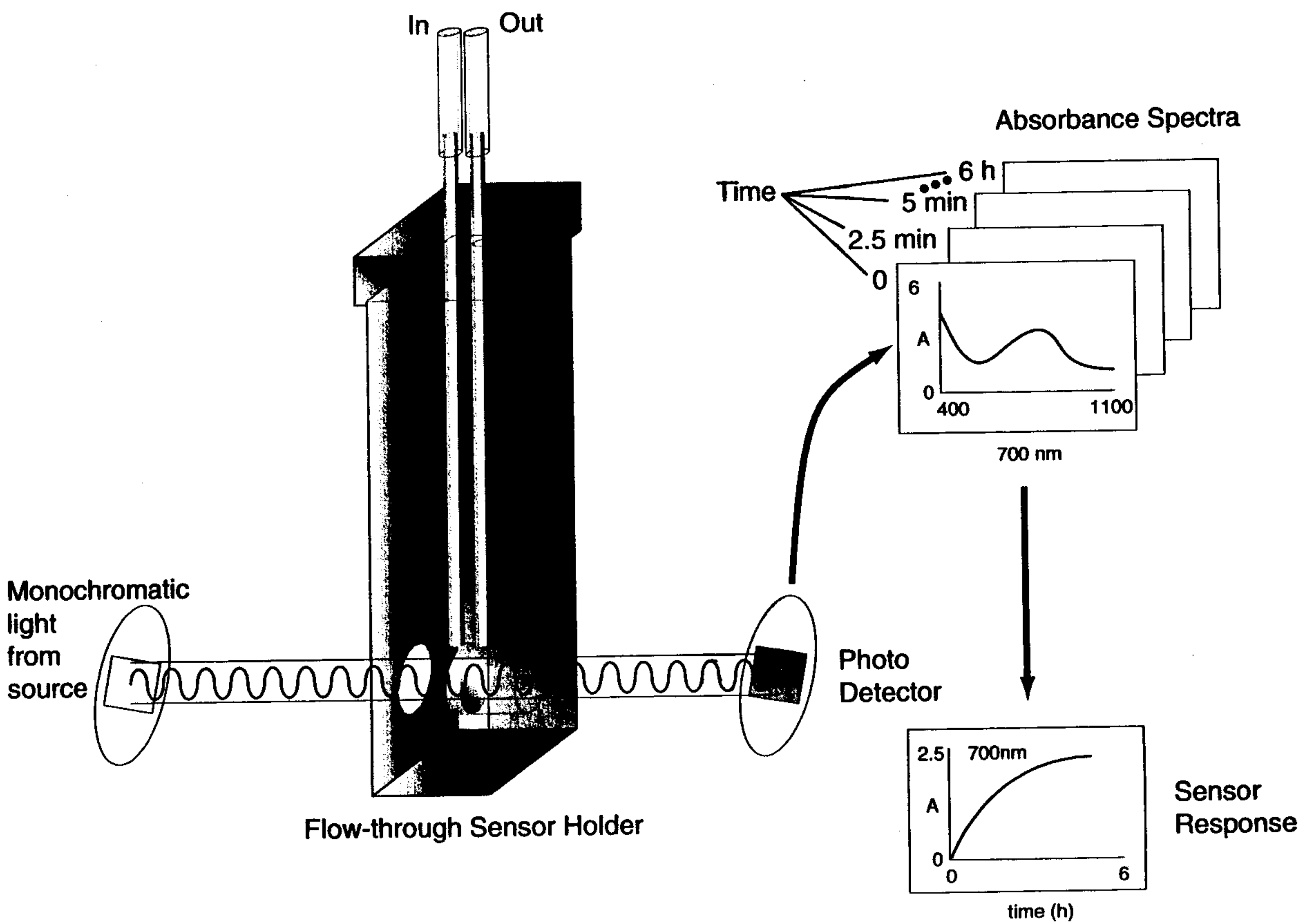
QGI Sensor Chemistry

1. $PdCl_3$ and MoO_3 coating on porous Si disk.

2. CO diffuses into pores and is oxidized to CO_2.

3. Yellow Mo(VI) on surface reduced to Mo blue.

4. Quantitative conversion of Mo(VI) to Mo blue.



In
Out
Monochromatic light from source
Flow-through Sensor Holder
Photo Detector
Time
0
2.5 min
5 min
6 h
Absorbance Spectra
6
A
0
400
1100
700 nm
2.5
700nm
A
0
0
6
time (h)
Sensor Response

Spectrophotometric Analysis

Beer-Lambert law: $\log (I_0/I) = abc$

$\log (I_0/I)$ = Absorbance

a = Molar absorptivity

b = path length of sensor

c = concentration (Mo blue)

Passive Sampler Diffusion

Fick's Law governs diffusion of gas along a tube due to a partial pressure gradient

Assumption -- 100% collection efficiency

$$\mathbf{M = D_{co} C A t / L}$$

M = mass diffused to end of diffusion tube (g)

D_{co} = diffusion coef. for CO in air (0.245 cm^2/sec)

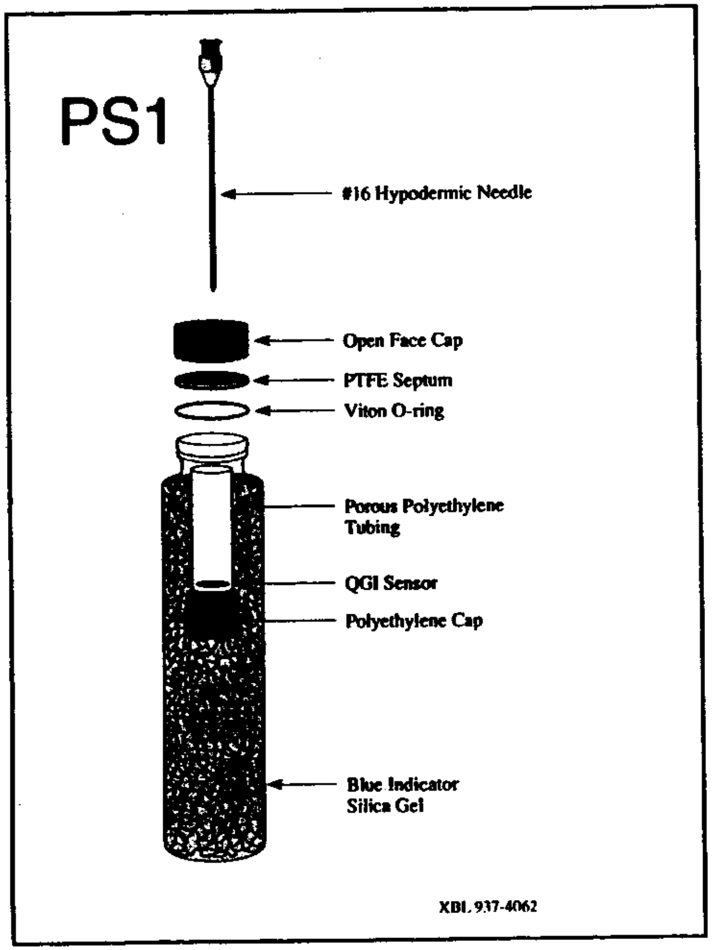
C = bulk air CO concentration (g/cm^3)

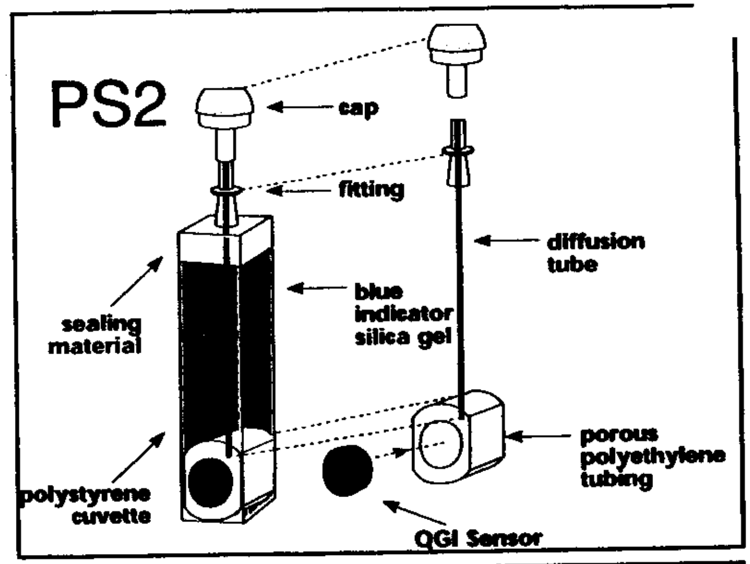
A = cross-sectional area of tube (cm^2)

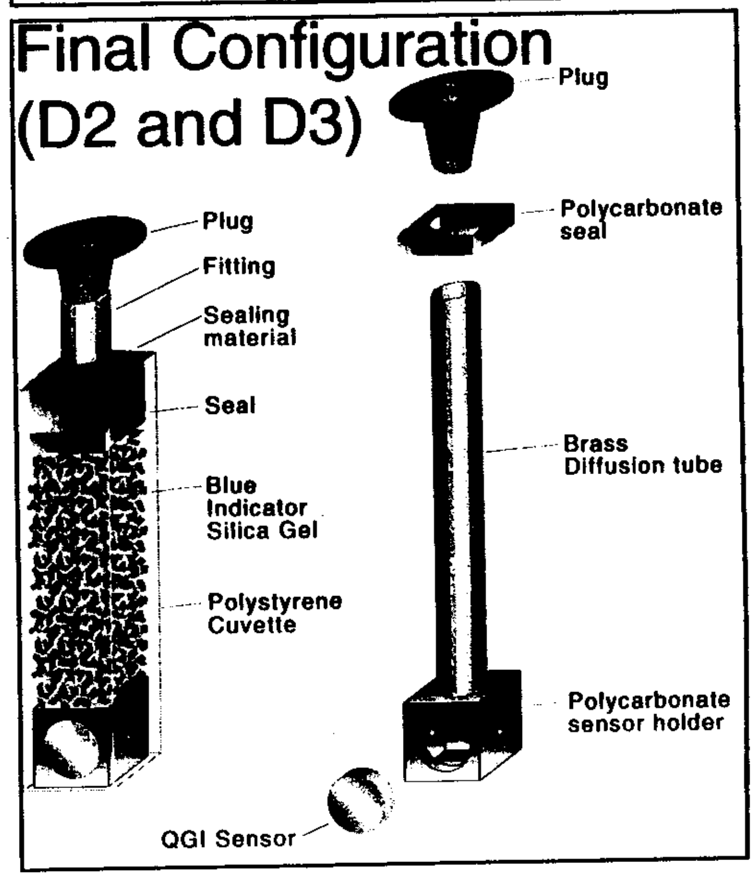
t = sampling time (sec)

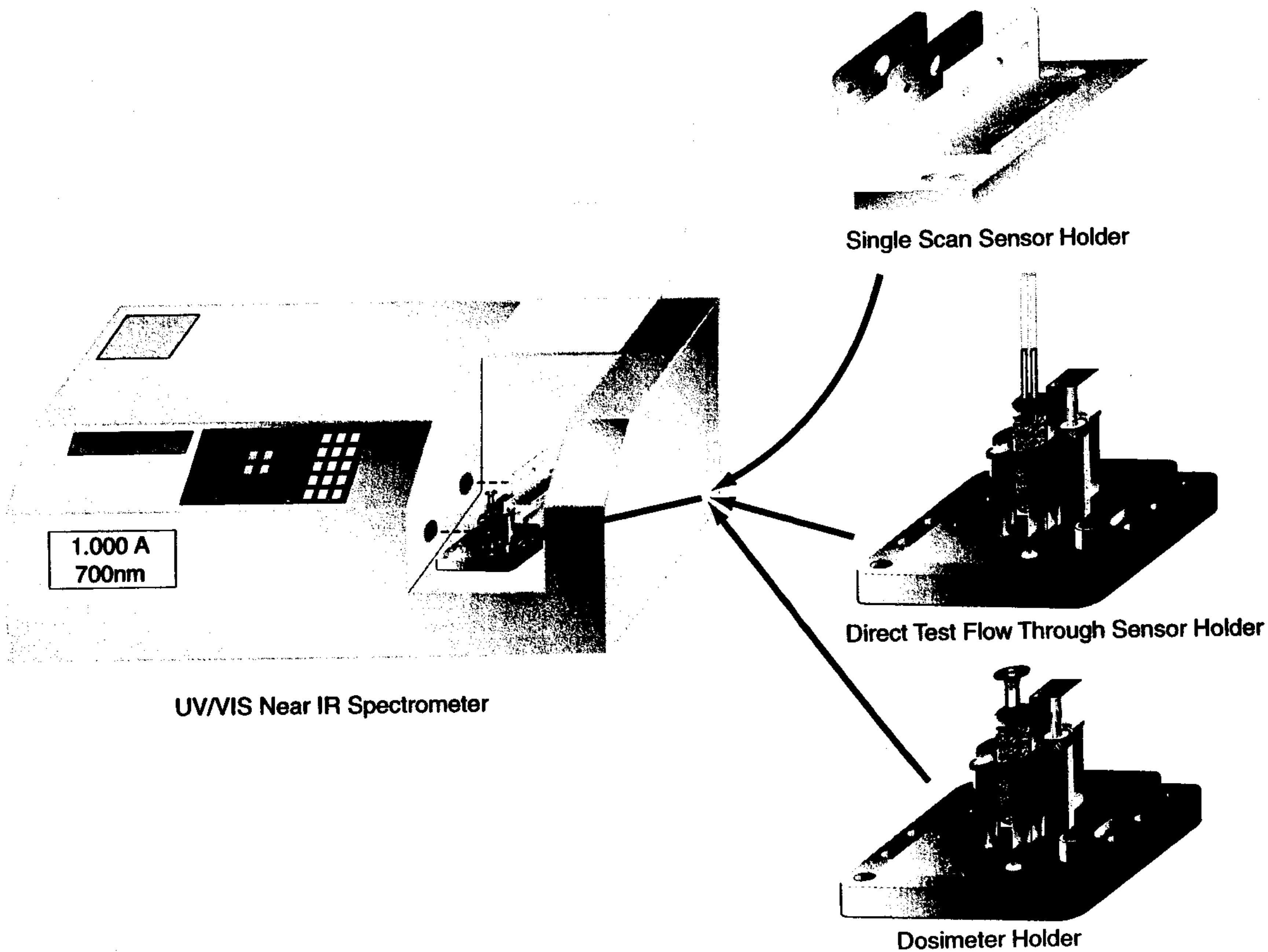
L = length of tube (cm)

LBNL/QGI Passive Sampler/Dosimeter Designs



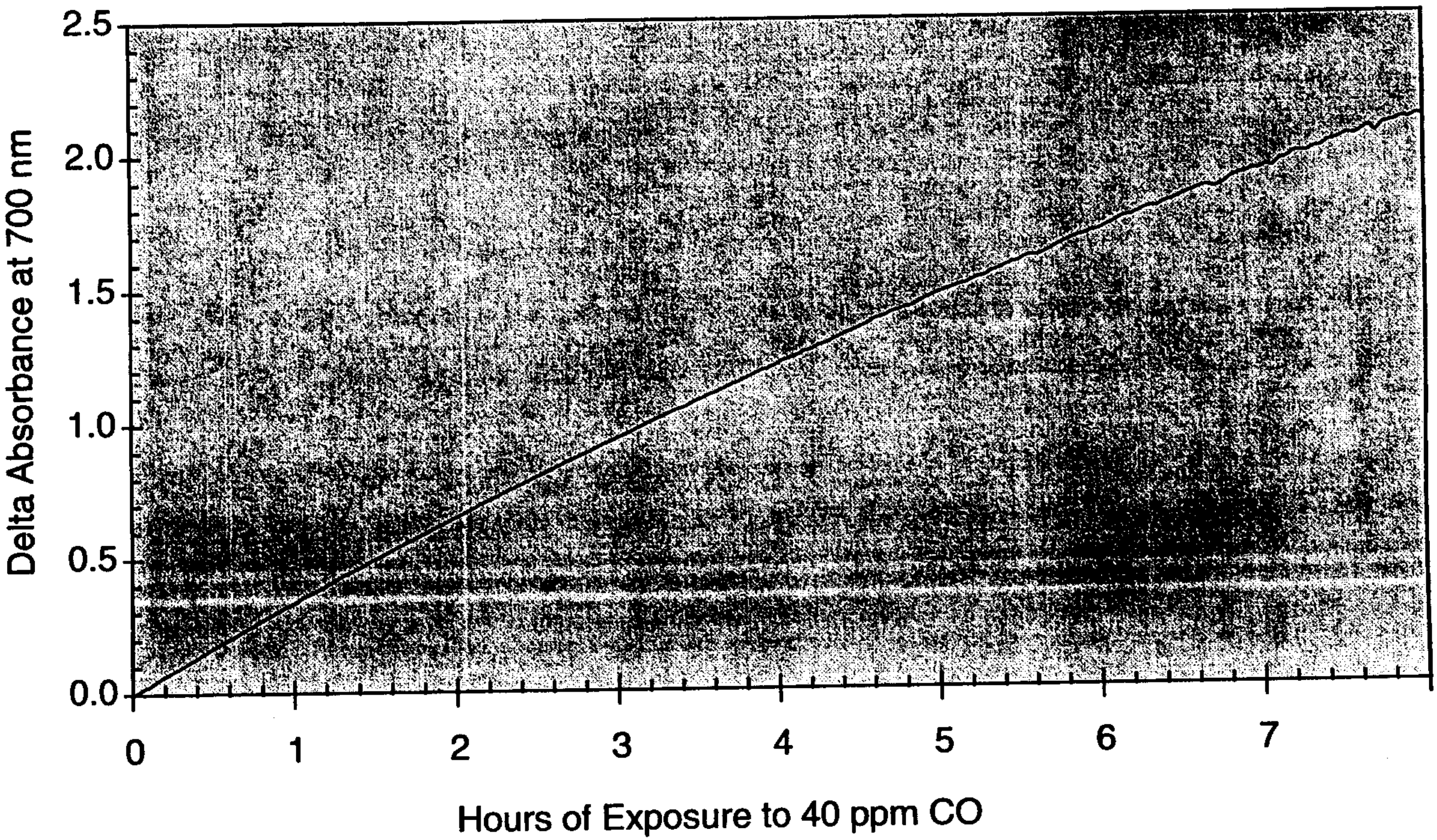




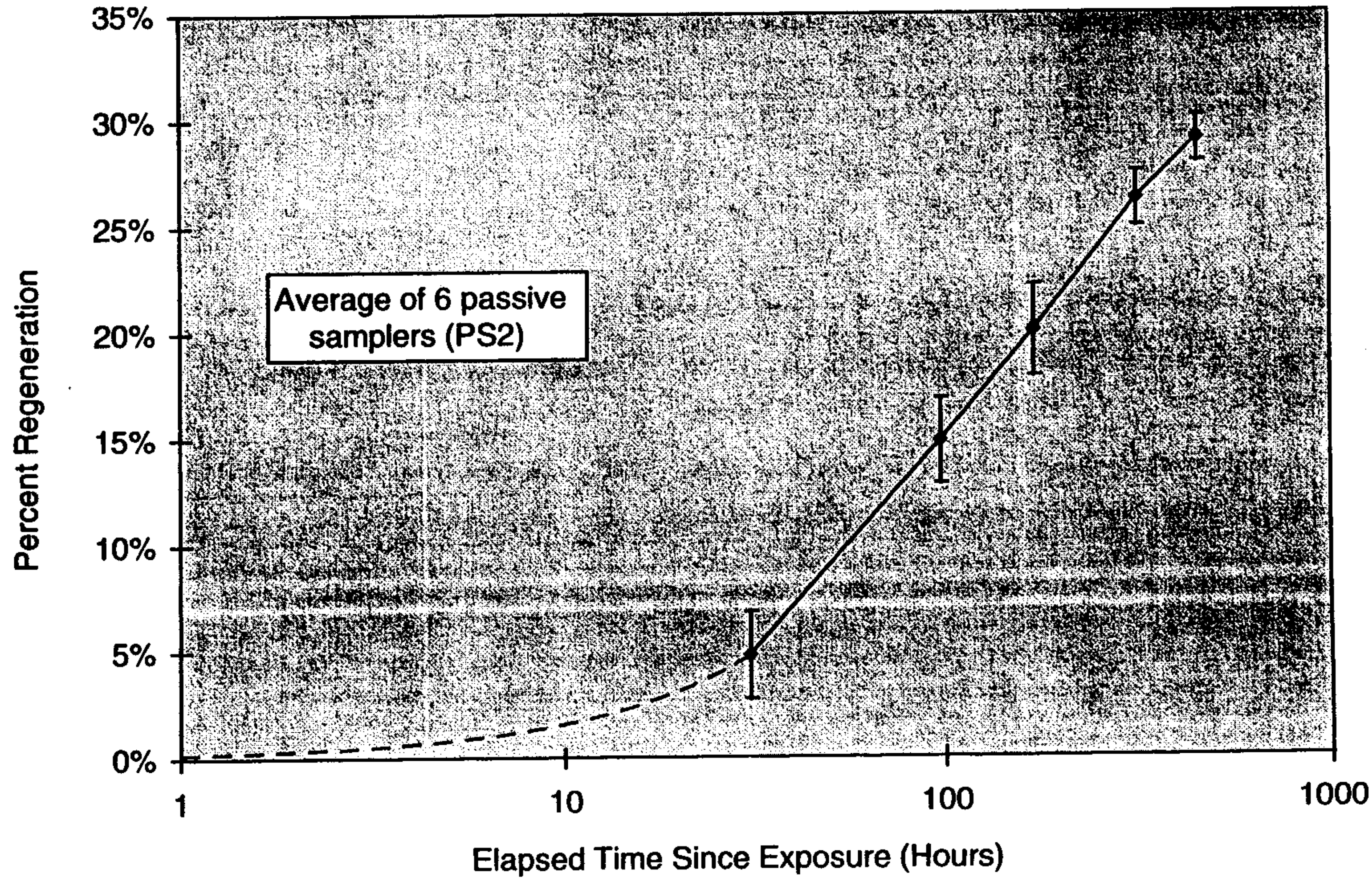


Single Scan Sensor Holder
Direct Test Flow Through Sensor Holder
Dosimeter Holder
1.000 A
700nm
UV/VIS Near IR Spectrometer

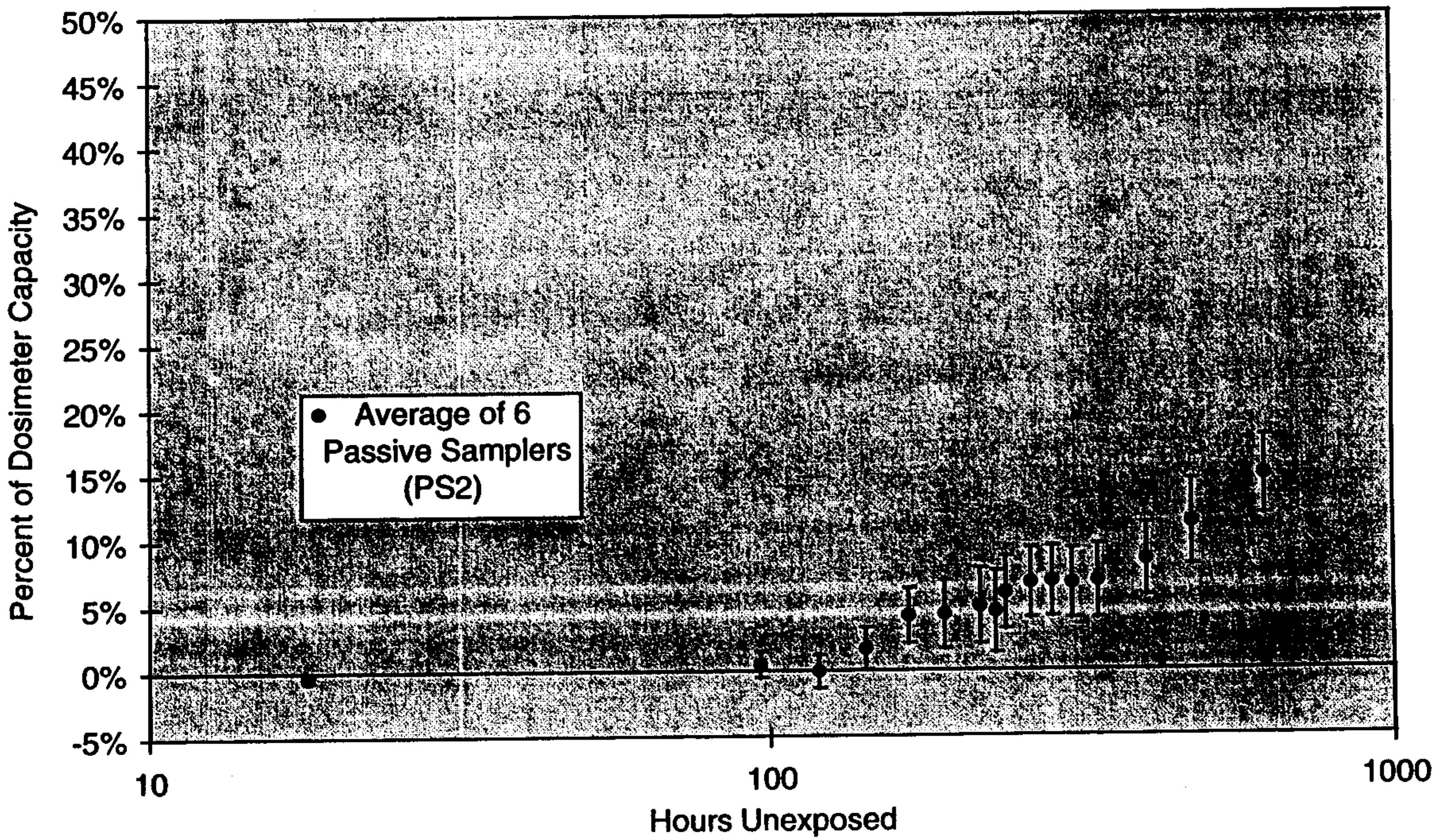
Typical QGI Sensor Response Profile



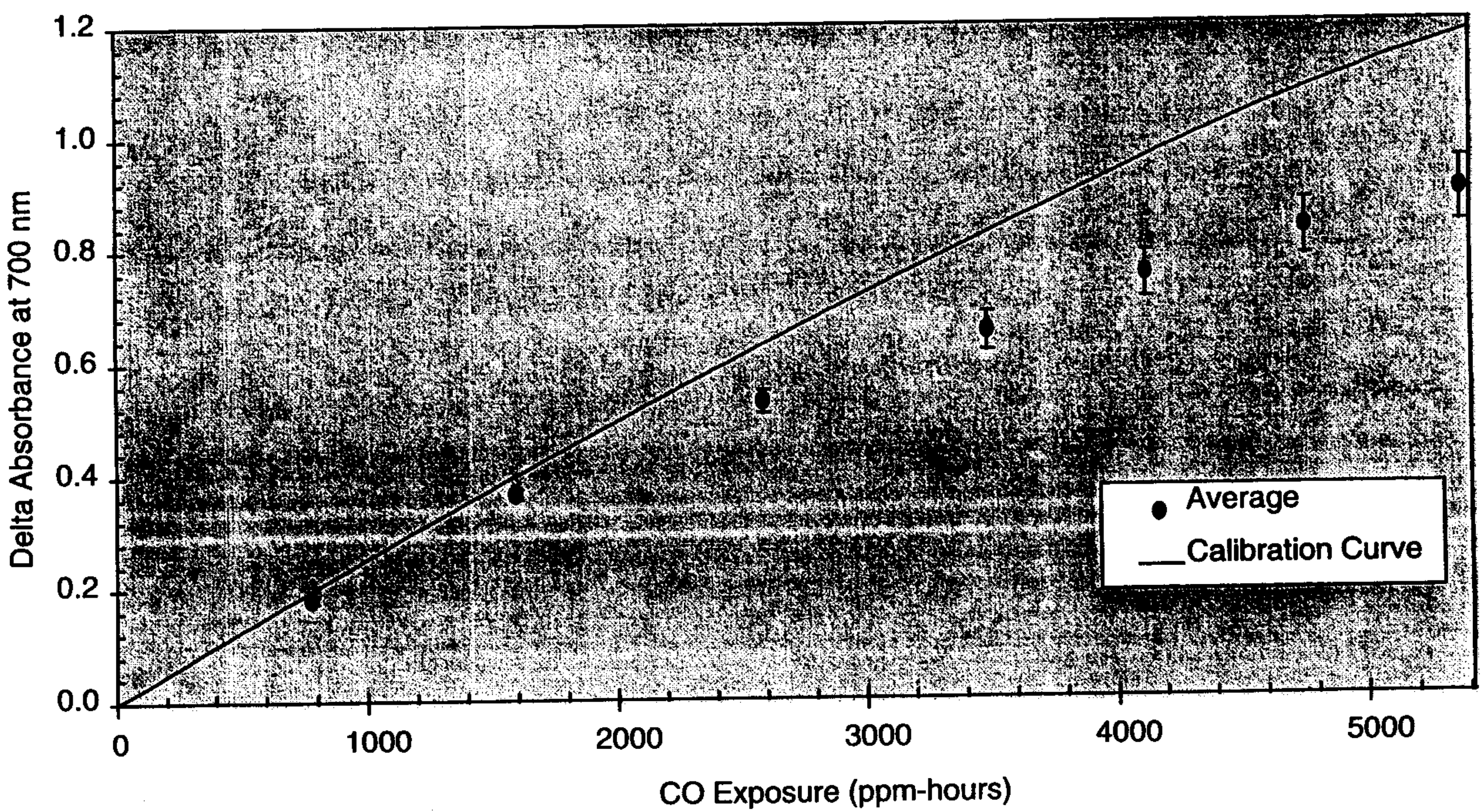
Sensor Regeneration



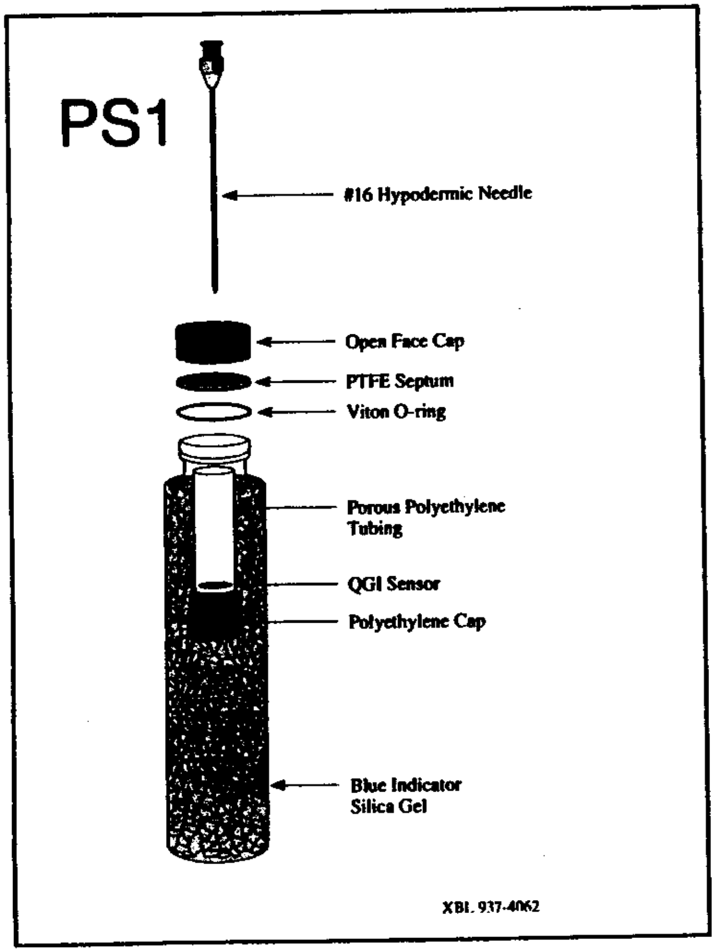
Unexposed Controls - Shelf Life

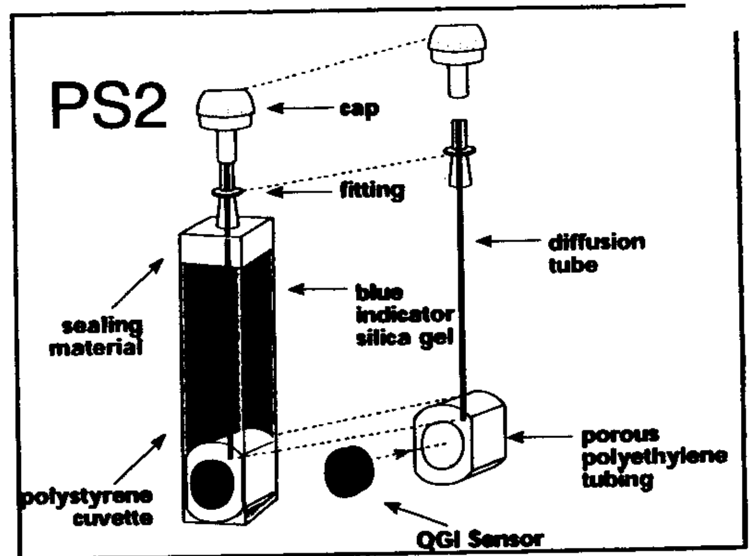


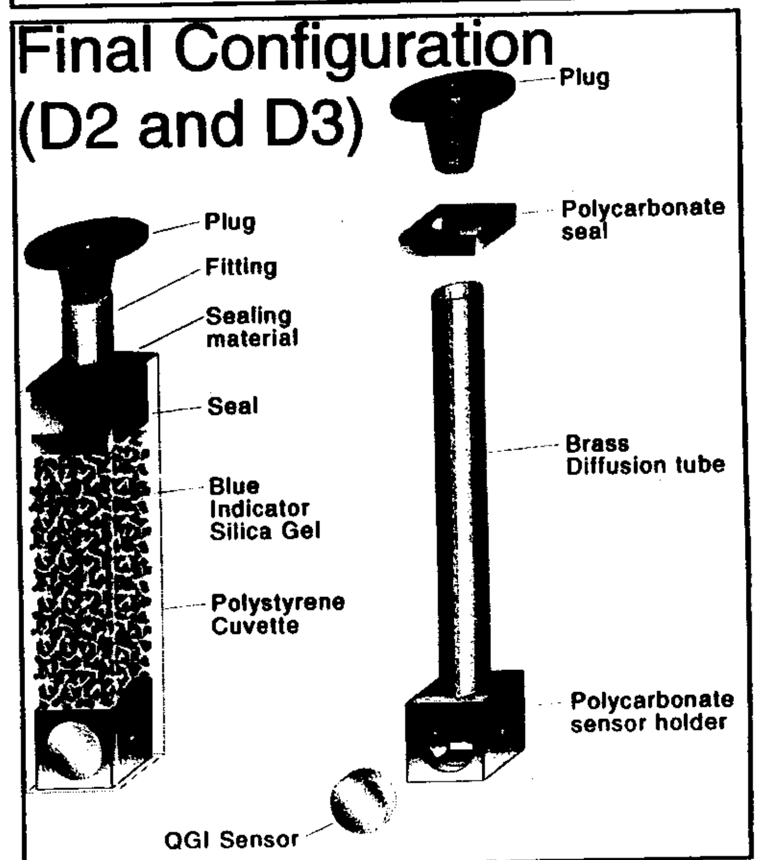
CO Response: High Humidity (PS2)



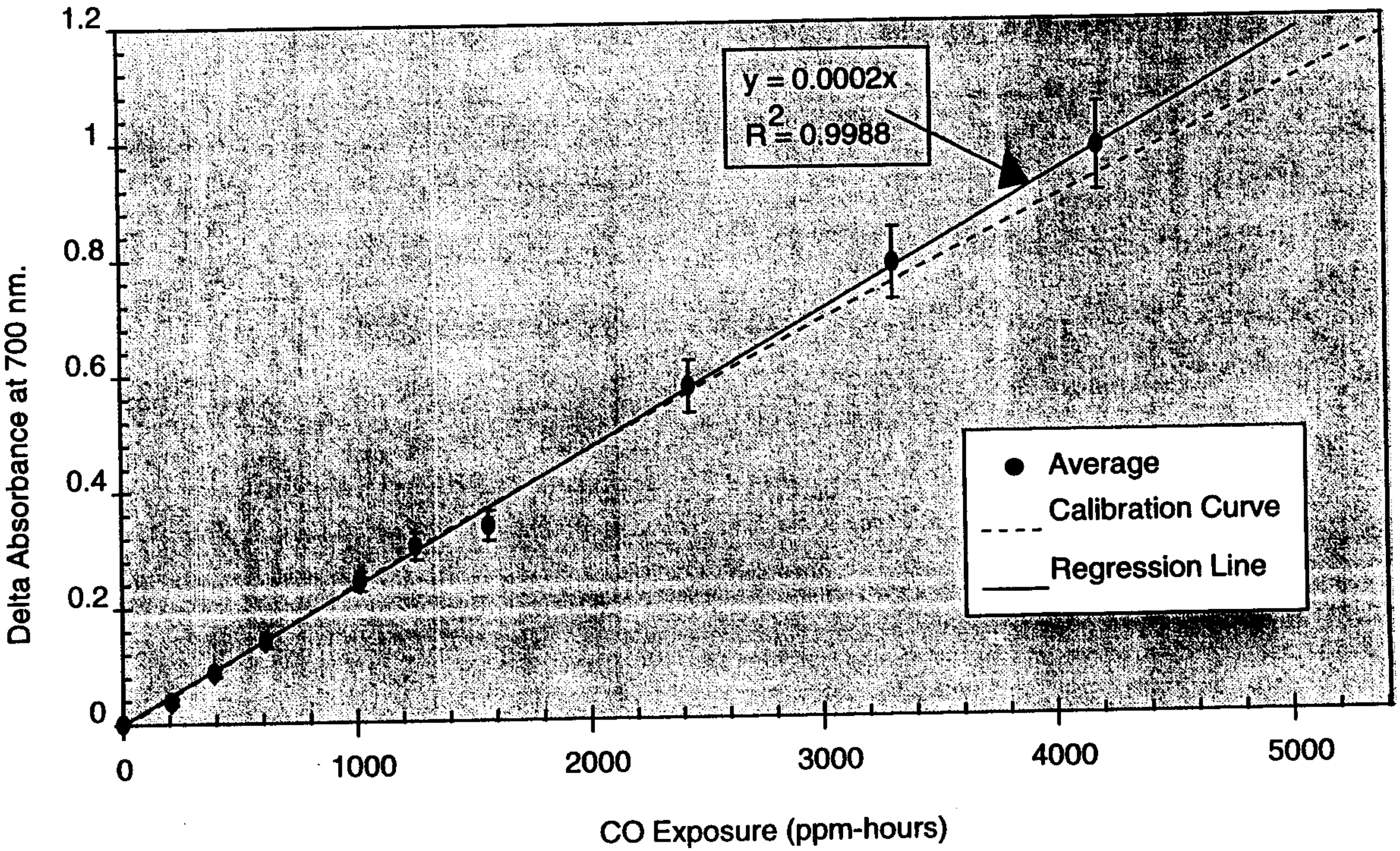
LBNL/QGI Passive Sampler/Dosimeter Designs



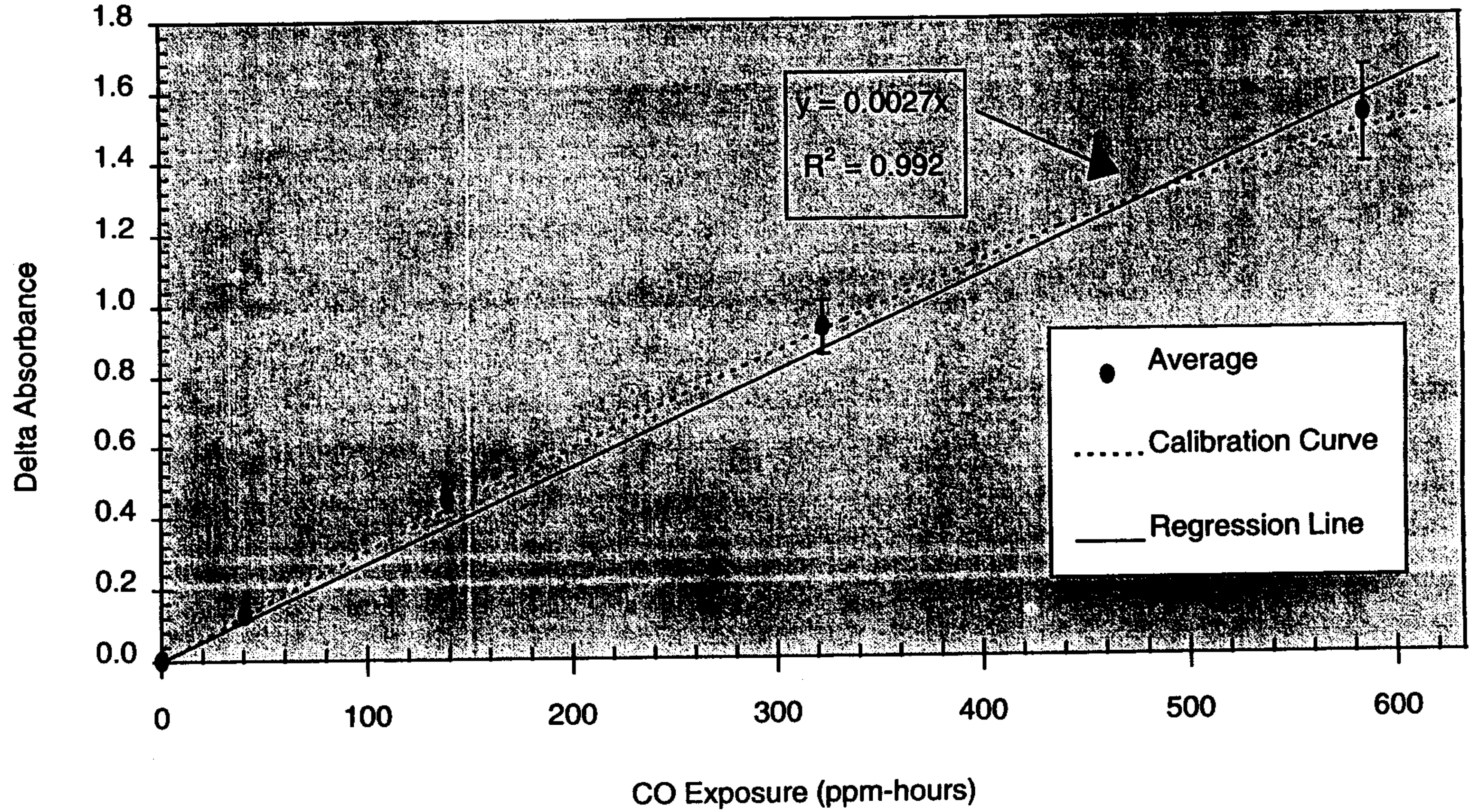




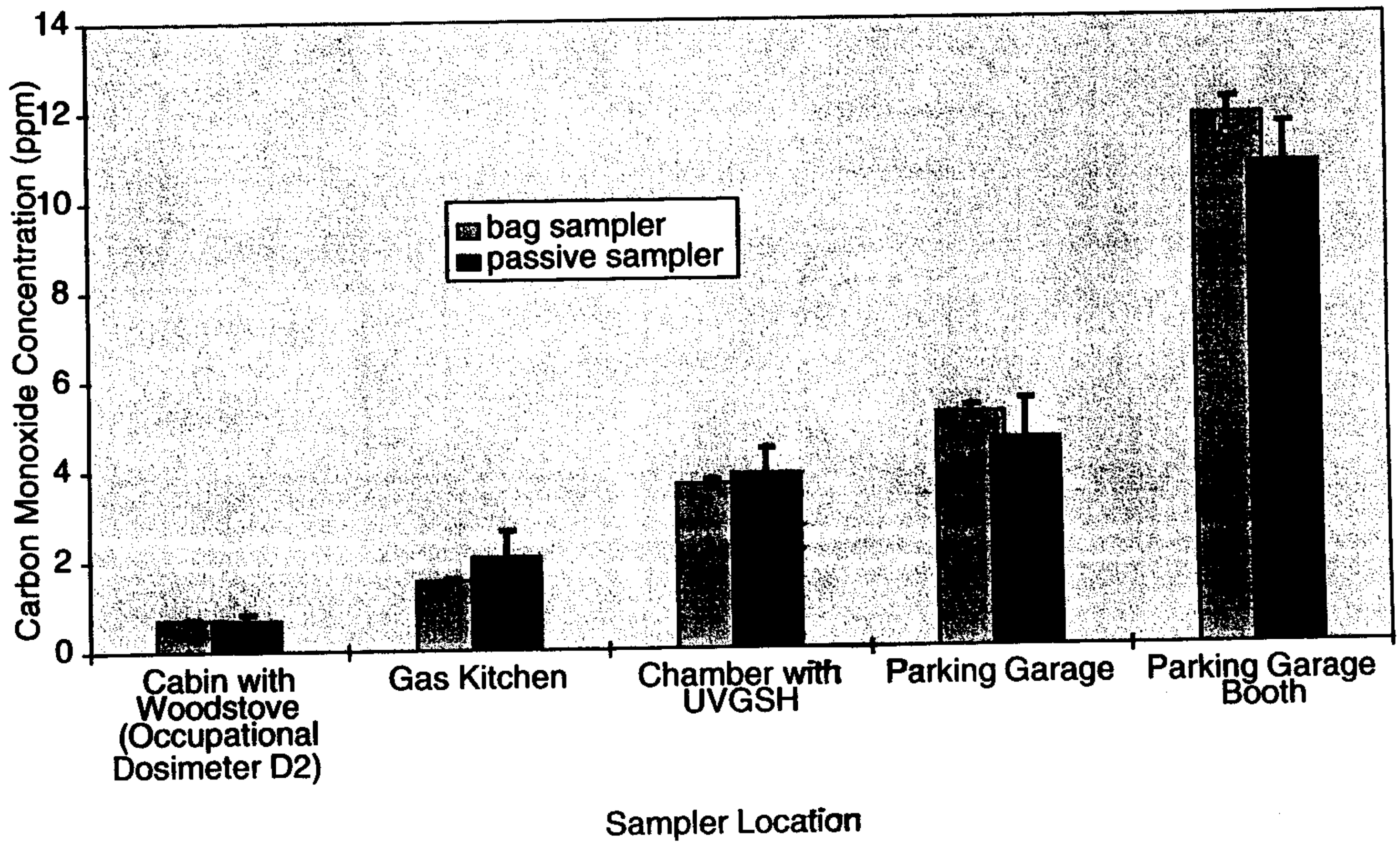
CO Response Data: Passive Sampler (PS2)



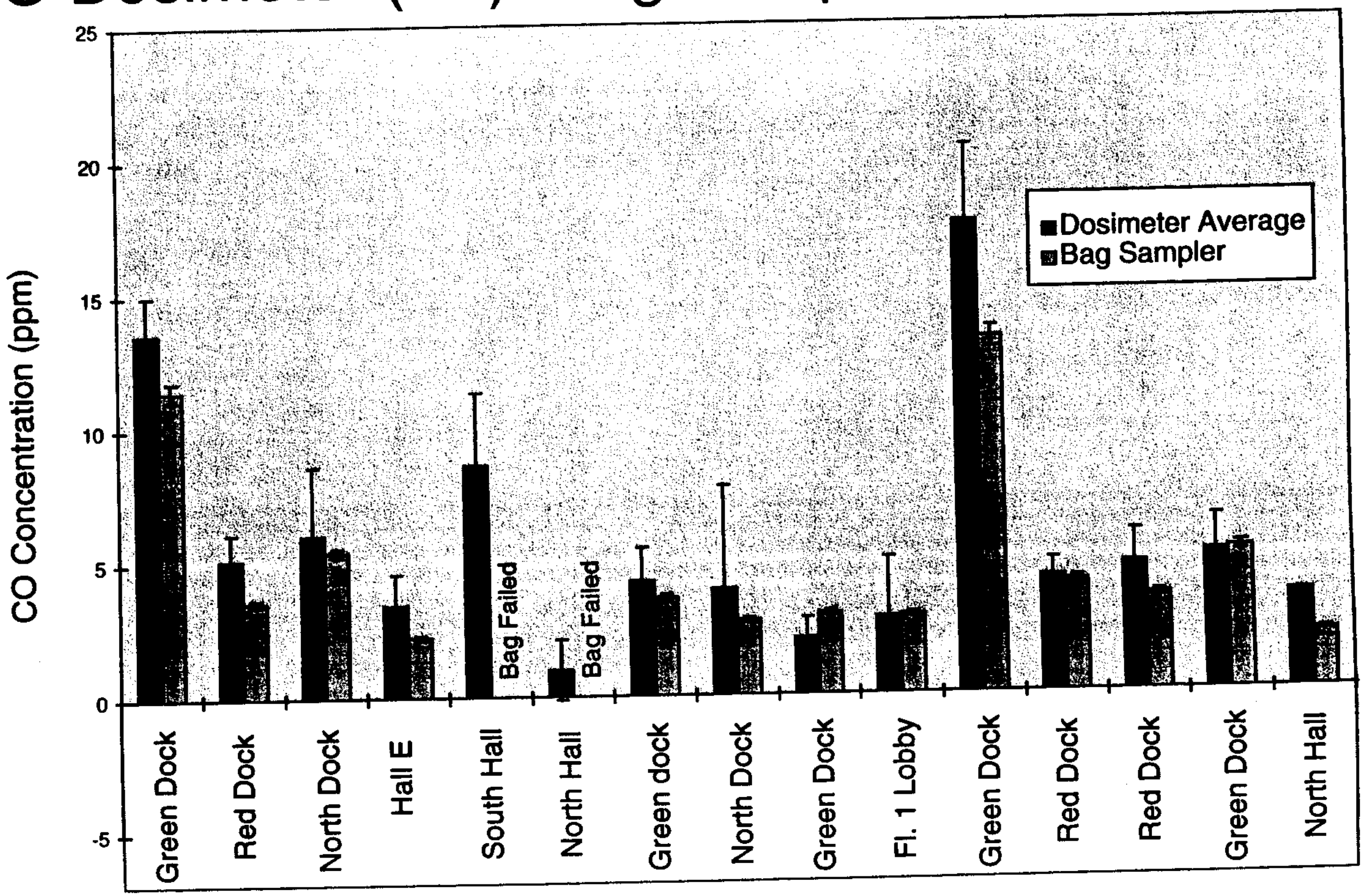
CO Response Data: Occupational Dosimeter (D1)



CO Passive Sampler (P2) Preliminary Field Results

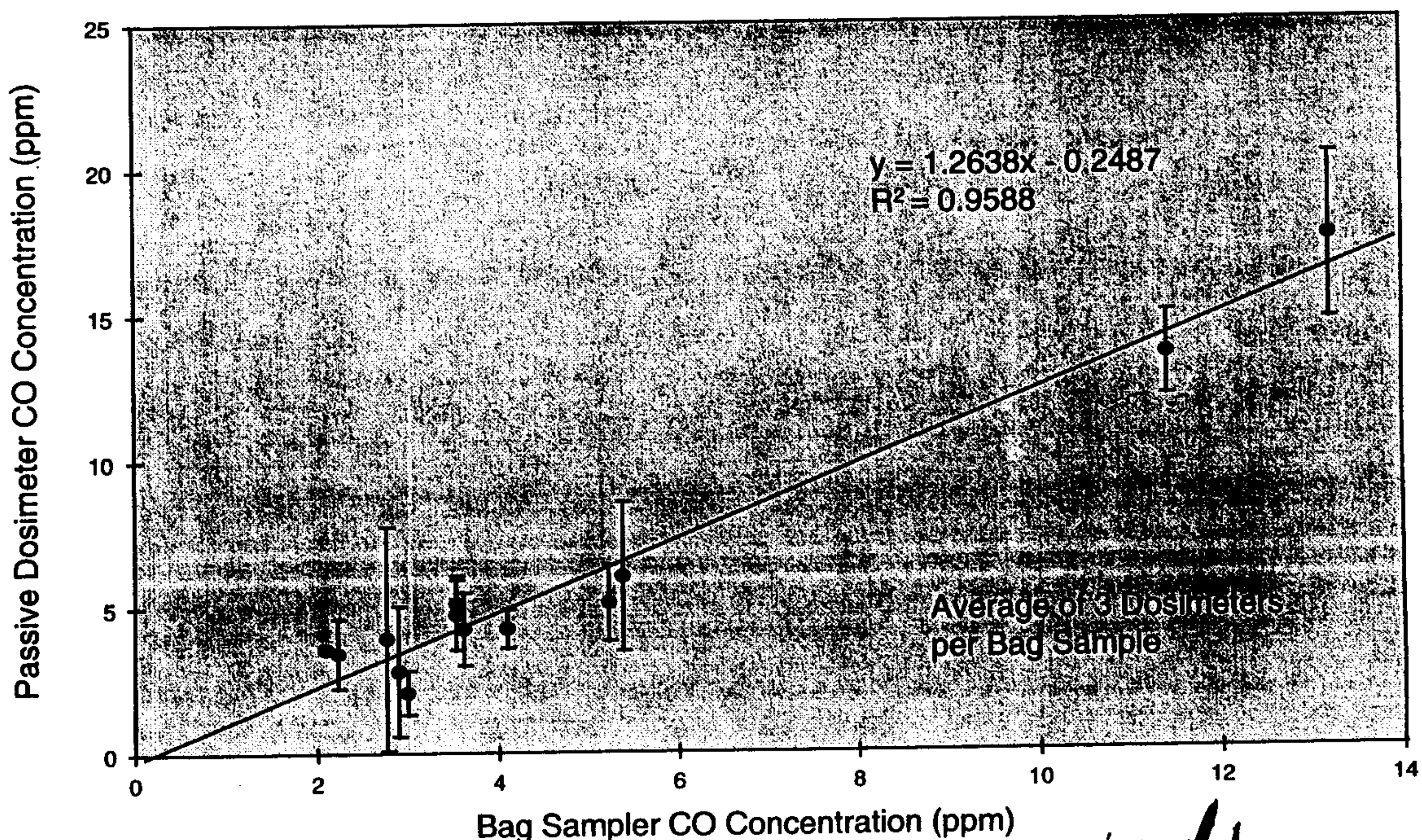


Problem Building - Moscone Convention Center
CO Dosimeter (D2)- Bag Sampler Comparison



Dosimeter (D2) - Bag Sample Comparison

Moscone Convention Center



Planned Publications - 1997

BERKELEY LAB

Development of a carbon monoxide occupational dosimeter, M.G. Apte, M.K. Goldstein, G.W. Traynor, M. Oum, and L.A. Gundel (for Journal of Exposure Analysis and Environmental Epidemiology).

Comparison of CO detector responses to potential interfering gases, L.A. Gundel and M.G. Apte (for American Journal of Public Health).

Field evaluation of a CO occupational dosimeter in workplaces with vehicle exhaust, M.G. Apte, D. Cox, S.K. Hammond, W.B. Helfman and L.A. Gundel (for American Industrial Hygiene Association Journal).

Comparison of occupational CO exposure assessment by passive dosimetry to breath diagnostics, M.G. Apte, S. Gourley and D. Cox (for Journal of Occupational Medicine).

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Future Research

- Effects of potential interferent pollutants on CO sensors with various technologies, and
- Population-based CO exposure assessment in indoor environments with combustion sources.

General Benefits

- The environmental quality of some commercial and occupational settings will be improved by finding and correcting high CO environments.

- Improved worker health for those exposed to CO on the job.

- Residential CO exposure assessment will be possible using a narrower diffusion tube.