IV. DIRECT MEASUREMENT LABS

Introduction

An industrial hygienist frequently needs to evaluate airborne gas and vapor concentrations "on the spot". In other cases, he needs to track down the sources of emission or to follow the increases and decreases in their concentrations as processes change during a shift and throughout the workplace. Direct reading instrumentation addresses this need by giving an instantaneous response that can follow changing concentrations with time, and by providing the ability to interface with data loggers or recorders to profile exposures over time.

In warehouses and chemical companies, the exposures to solvents, carbon monoxide, formaldehyde, and carbon dioxide lend themselves to direct measurement techniques. In these experiments the chemical exposures will be simulated from laboratory-supplied cylinders containing either one or two compounds in air.

I. Purpose

a. To become familiar with the principles of operation, the proper use and the limitations of detector tubes.

b. To experiment with and evaluate a variety of direct reading methods and to compare the accuracy and ease of use of the methods.

c. To carry-out real-time data collection and analysis with these devices.

II. References: (Supplementary to instrument manuals on file in F226 reprints box)

Air Sampling	D.R. Tubes & badges	pgs 458-470
Instruments (ASI)	D.R.G. & V Instruments	pgs 507-517
Ness	Sampling Bags	pgs 74-76
	Detector Tubes	pgs 297-311
	Carbon Monoxide	pgs 180-185
	FID and/or PID	pgs 220-233
	Formaldehyde	pgs 68-74
Perkins	Instruments for Gases and Vapors	pgs 603-663
SKC	Catalog	
NIOSH, NMAM	CO, NMAM 6604	

II. Outline

The Lab is divided into two parts and each part will require one complete lab period. The gas sample sources that are evaluated in Part 1 will again be measured in Part 2. This laboratory is arranged so that you become acquainted with a number of direct reading measurement techniques. Individual instrument manuals will be available in the laboratory & F226, & simplified or brief instructions are provided with the laboratory manual. All direct reading instrumentation will require a calibration process with gases of known concentration. For this, "span" gases of the relevant compounds are provided in compressed gas cylinders of air.

Part 1: Detector tubes

Equipment:

a. Draeger (Accuro) pumps and RAE Piston type pumps
b. Draeger and Rae Detector tubes
c. Sample bags
d. Bubble burette
e. Span gases: [CO, CO_2, Toluene, Trichloroethylene (TCE)]

As one of the most commonly encountered industrial hygiene measurement devices, detector tubes have attained wide general acceptance because of their low cost, simplicity, wide range of application, and immediate readout.

NIOSH established a certification program to assure that tubes meet certain minimum performance criteria. These criteria include accuracy of ± of 25% of the stated calibration down to 0.5 TLV, where the tube variability cannot exceed ± 35%*. In addition, there are requirements for the following: (1) labeling instructions, (2) quality control records of chemical calibration which must be made and kept by the manufacturer, (3) length of stain at the TLV must be ± 15mm, and (4) there must be minimum channeling effect. Additional requirements relate to the pump volume accuracy (± 5%) and flow rate (± 10%). The tubes are approved as a system together with a specific pump and sampling rate; therefore, the protocols suggest that tubes are not interchangeable from one manufacturer to another.
* NIOSH discontinued in 1983, but manufacturers continue to meet the accuracy criteria.

Procedure:

1. Perform a leak test on the Accuro bellows pump by inserting an unbroken tube and depressing the bellows. Wait 2 minutes and if the bellows distend (or the chain becomes taut), there is excessive leakage. If the bellows do not displace and/or the chain remains loose, there is no significant leakage. With the Accuro pump, check for complete compression. Repeat the tests with a RAE Pump for piston displacement.

2. Perform a volume test on the Accuro pumps utilizing a bubble burette. Repeatedly, the delivered volume should be within ± 5% of the rated amount of 100 ml.

3. Fill a pre-conditioned bag with the calibration span sample gas (one bag for each gas). Following the directions for the detector tubes, determine the readout on the detector tubes. Obtain multiple (replicate) readings on each tube and draw multiple samples from each bag (minimum 3). Test for CO, CO2, Toluene, and Trichloroethylene with the appropriate tubes for the appropriate bag samples. The table below lists the samples that should be analyzed:

Sample	Concentration
CO_2	1500 ppm
CO	25.7 ppm
CO and CO_2 mix	CO: ?? ppm, CO_2: ??
Toluene	50 ppm
TCE	50 ppm
Toluene and TCE known mix	Toluene: 50 ppm, TCE: 50 ppm
Toluene and TCE unknown mix	Toluene: ?? ppm, TCE: ?? ppm

4. The Rae Tubes may be outdated but can still give comparison readings on the same sample bags.

Part 2: Direct-reading instruments

Equipment:

a. Sampling bags
b. CO_2 Analyzer (Horiba)
c. CO Monitor (MSA Passport)
d. Photovac TIP (PID detector)
e. Organic Vapor Monitor (FID detector)
f. Q Trak Indoor Air Monitor (CO, CO_2, Temperature, RH)
g. Other Meters- CO meter
h. Dilution Syringes
i. Known and unknown Gas Mixtures

Response of a direct reading instrument is directly related to concentration; so calibration is a two-point calibration with a zero point and one calibration span gas point with assumed linearity. The following six- step procedure is generic for direct reading instruments (additional steps for Passport):

1. Read operating instructions and review function of the dials, knobs and buttons.
2. Turn on instrument and allow it to warm up **at least 5 minutes**.
3. Zero the meter with a zero gas or with contaminant-free room air.
4. Attach span gas to sampling probe, note the response time and then adjust span control to read the corresponding, known concentration.
5. Recheck zero. If changed; re-zero and re-span instrument until zero and span are constant and stable.

6. Analyze unknown samples.
7. Recheck zero and span to detect drift where excessive (>3 hrs.) time has elapsed.

Experimental Procedure

The carbon monoxide and dioxide analyzers are single component analyzers. They are examples of simple direct reading instruments. Work with these monitors first; then move to the more complex PID and FID detectors. The PID and FID detectors will be determining a two component mixture collected at the paint filling station. The instructions below apply to all direct reading instruments. Start with the carbon dioxide and carbon monoxide meters first. Passport and the Qtrak are examples of multiple gas meters.

IN-LABORATORY EXERCISES

1. Fill a pre-conditioned bag with a known-concentration span gas and zero gas, if needed, for the respective instrument and calibrate the instrument. ***If you wish, use the liter size syringe to dilute the span gas in order to measure a few intermediate concentrations and to check that the instrument response is linear.***

2. Now, attach the sampling probe of the operational and calibrated instrument onto the appropriate sample bag. Record the results and the source of the sample.

   Repeat steps 1 & 2 with all direct reading instruments.

The table below indicates which measurements should be made with which instruments:

Sample	Q-trak	Horiba	Passport	PID	FID
CO CO_2 CO/CO_2 mix					
Tol TCE Tol/TCE known Tol/TCE unknown					

"OUT OF LABORATORY" DATA COLLECTION (CO2, CO, RH, and Temperature)

3. With an instructor's assistance, attach the data logger to the monitor. Place the monitor and logger in room F-225 or F-226. Turn on the Q-Trak and leave operating for approximately two days, then stop data logging and shut off the analyzer, and download the data to the PC in T564. Plot the data with Microsoft Excel.

Write-up

Part 1:

1. Prepare a table for all calibration span gas samples. The table should include the readings, mean, standard deviation and coefficient of variation, and indicate whether the specific tube would pass the NIOSH Criteria. Discuss any conclusions regarding the application of detector tubes. (Keep it brief, two paragraphs or less).

2. In a second table list your results for the unknown samples. The table should include the readings, mean, standard deviation and coefficient of variation.

Part 2:

1. Prepare a table showing instrument identification, concentration of span gas used when calibrating, and results for both the known and unknown samples. Compare different instruments that measured the same vapors. Did the readings drift?

2. Compare the direct reading instrument results with detector tube results. What conclusions can be drawn for each case? Which instruments seemed to be most reliable?

3. Provide the chart describing Carbon Dioxide, Temperature and Humidity for the selected room. Discuss the stability, variation with time and the relation to standards. What conclusion can be made from this monitoring?