

SAMPLING AND ANALYSIS

747

ducing a stoichiometric relationship between the volume of stained indicating gel and the quantity of the absorbed test gas. Such equilibrium conditions may be assumed to exist when stain lengths are directly proportional to the volume of sampled air and are not affected by the sampling flowrate. With this situation a log-log plot of stain length versus concentrations for a fixed sample volume may be prepared in the calibration of a given batch of tubes.

From the preceding discussion of the complexity of the heterogeneous phase kinetics of indicator tube reactions, the quality control problems associated with their manufacture and storage, and the difficulties posed by interfering substances, it is obvious that frequent, periodic calibration of these devices should be made by the user. Dynamic dilution systems for the reliable preparation of low concentrations of a test gas or vapor are recommended for this purpose. The Department of Health, Education and Welfare has issued regulations for the certification of gas detector tube units (18). The performance requirements for these units were developed by the NIOSH Division of Laboratories and Criteria Development, with the cooperation and assistance of members of the Joint Direct Reading Gas Detecting Systems Committee of the AIHA and the ACGIH. Table 17.4 lists the detector tubes that have been certified to date (March, 1977) by this program, and the manufacturer or supplier.

4.3.4 Passive Personal Monitors

In recent years significant progress has been made in technology for monitoring of gases and vapors using binary diffusion. The monitors utilize Brownian motion to control the sampling process into a collection media. This technology is particularly well suited for personal monitoring devices, resulting in lightweight, low cost monitors that require no power source.

The monitors rely on a concentration gradient across a static or placid layer of air to induce a mass transfer. The following equation, based on Fick's law, gives the steady state relationship for the rate of mass transfer.

$$W = D \left(\frac{A}{L} \right) (C_1 - C_0) \quad (6)$$

where W = mass transfer rate

D = diffusion coefficient

A = frontal area of static layer

L = length or depth of static layer

C_1 = ambient concentration

C_0 = concentration at collection surface

It can be seen that by choosing an effective collection surface, such that C_0 is essentially zero, the mass transfer or collection rate is proportional to the ambient vapor concentration C_1 . It may also be noted that the units of $D(A/L)$ are volume per unit time, the same as for the volumetric flow in a pump monitoring system. The rate of

Table 17.4 NIOSH-Certified Detector Tubes^a

SUBSTANCE	MANUFACTURER			
	Dräger Model 31	Gastec Model 400	Kitagawa Model 400	MSA Universal
Acetone	-	-	-	460423
Ammonia	CH 20501	3M	105Sc, 105c	460103
Benzene	67-26641	121	-	-
Carbon Dioxide	CH 23501	2L	126Se, 126s	85976
Carbon Monoxide	CH 25601, CH 20601	1La	106S, 100	91229
Carbon Tetrachloride	-	134	-	-
Chlorine	-	8La	-	460225
Hydrogen Cyanide	CH 25701	-	1123b	-
Hydrogen Sulfide	67-19001	4LL	120b	460058
Nitric Oxide	CH 31001	10	-	-
Nitrogen Dioxide	CH 30001	9L	-	93099
Sulfur Dioxide	CH 31701	5La	103Sd, 103d	92623
Toluene	CH 23001	122	-	-
Trichloroethylene	CH 24401	132H	-	-

^a Names and addresses of manufacturers and distributors of detector tubes:

Bendix Corporation
1400 Taylor Avenue
Baltimore, Md. 21204
(Gastec distributor)

Matheson Gas Products
1275 Valley Brook Avenue
Lyndhurst, N.J. 07071
(Kitagawa Distributor)

Mine Safety Appliances Company
400 Penn Center Boulevard
Pittsburgh, Pa. 15235

National Mine Service Company
3000 Koppers Building
Pittsburgh, Pa. 15219
(Dräger distributor)

sampling of the contaminant is then the product of the $D(A/L)$ term and the average ambient concentration.

Figure 17.10 illustrates the construction of a monitor for mercury vapor in which the collection surface is a gold layer (19). A similar configuration (Figure 17.11) has been developed for nitrogen dioxide (20). In the case of the mercury monitor, mercury vapor in the atmosphere passes through the microporous barrier film and continues through

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the static air column according to Fick's law. The average time required to reach the collection surface is

$$T = \frac{L^2}{2D} \text{ seconds} \quad (7)$$

For example, the average time for a mercury atom to progress to the collection surface when the depth L is 0.65 cm can be shown, using $D = 0.12 \text{ cm}^2/\text{sec}$, to be 1.75 seconds. Thus the sampling occurs rapidly when thin static air columns are used.

The accuracy and precision of the sampling process are functions of the measured exposure time, velocity effects, and temperature effects. The accuracy and precision of the reported concentration are functions of the calibration standards, collection media, and analytical method used. Of these factors, the potential velocity and temperature effects distinguish this type of monitoring device from the conventional dynamic or flow monitor. All other factors are common to both methods.

Regarding velocity effects, the thickness of the attached boundary layer on the outer surface of the barrier film is a function of the velocity of air movement over the face of the monitor. Sampling that is independent of this air velocity can be achieved when the L term is large compared to the average boundary layer thickness. For temperatures between 50 and 88°F, the temperature factor is constrained to ± 1.8 percent. For use at higher or lower temperatures, the temperature data may be rerecorded to allow corrections to be made.

This type of personal monitor is attached to the worker in his breathing zone. The total exposure time is noted, and analysis results give the amount of vapor collected. These data provide an average mass collection rate, which can then be used to calculate the time-weighted average concentration. The physical parameters of the sampler design are chosen according to desired exposure time and the substance to be monitored.

Corroborative testing of both the mercury and nitrogen dioxide monitors and comparison of results to reference methods have shown excellent agreement. With the

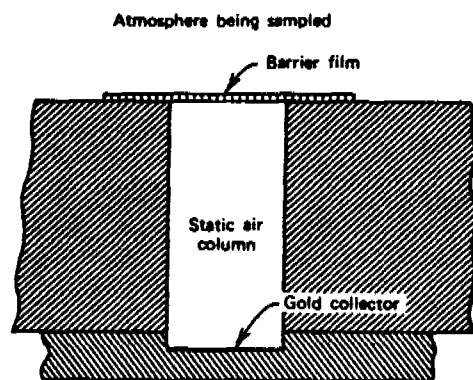


Figure 17.10 Cross-sectional view of mercury detector.

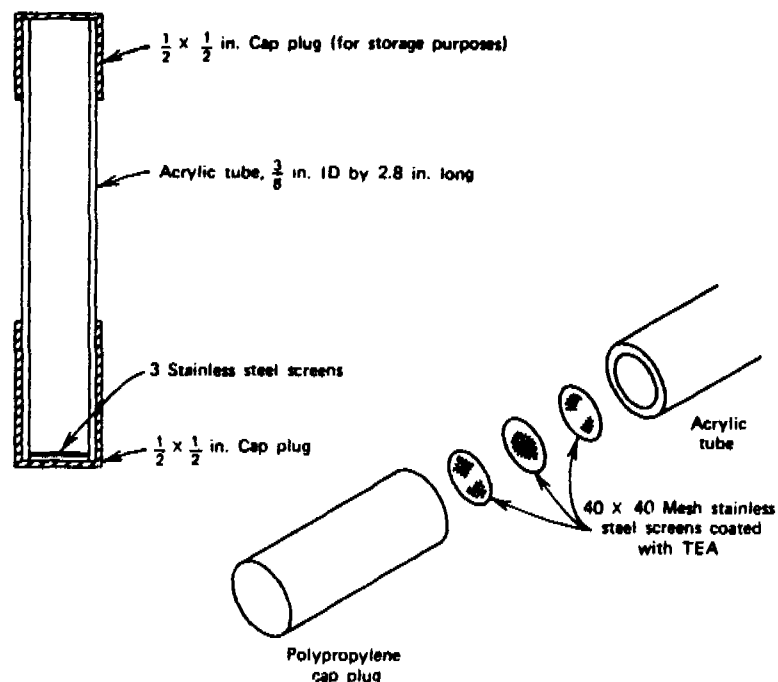


Figure 17.11 Exploded view of nitrogen dioxide monitor.

increasing emphasis on development of specific methods for monitoring workers' exposures to contaminants, it is likely that the passive monitor concept will become the vital basis for a new generation of industrial hygiene monitoring equipment.

5 SAMPLING FOR PARTICULATES

In classifying airborne particulates, the term "aerosol" normally refers to any system of liquid droplets or solid particles dispersed in a stable aerial suspension. This requires that the particles remain suspended for significant periods of time.

Liquid particulates usually are classified into two subgroups, mists and fogs, depending on particle size. The larger particles generally are referred to as mists, whereas small particle sizes result in fogs. Liquid droplets are normally produced by such processes as condensation, atomization, and entrainment of liquid by gases.

Solid particulates usually are subdivided into three categories: dusts, fumes, and smoke, the distinction among them being primarily related to particle size. Dusts are formed from solid organic or inorganic materials by reducing their size through some mechanical process such as crushing, drilling, or grinding. Dusts vary in size from the

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