MONITORING THE WORKING ENVIRONMENT

This articles lists chemicals to which people in different occupations could be exposed, their maximum acceptable levels, the methods of sampling for these compounds in the working environment, and the analytical methods. Details of the analytical methods are given in article XV-C.

INTRODUCTION

Many people are exposed to the chemicals they work with each day. Examples include

- petrol station attendants (benzene, hydrocarbons)
- veterinarians and their nurses during operations on animals (anaesthetics)
- painters (solvents, resins)
- welders (heavy metals)
- printers (solvents)
- gunners in the army (explosives, heavy metals)
- factory workers (plastic monomers, solvents)
- car mechanics (degreasing agents, hydrocarbons, benzene)
- panelbeaters (heavy metals, degreasing agents)
- electroplaters (heavy metals)
- potters (heavy metals, sulfur gases)
- farmers (pesticides and herbicides)
- demolition workers (asbestos)

and, of course, laboratory workers in a wide range of industries.

Many other people are exposed to chemicals from the environment. This may be anything from dust (eg quarries), particulate matter from engine exhausts (everyone!), sulfur gases (eg chimneys, but also geothermal activity) to formaldehyde released from particle board in buildings.

Employers are required by the Health and Safety in Employment Act to provide their employees with a healthy and safe working environment. For many, this will involve monitoring both the environment in the workplace, and the employees themselves for levels of harmful chemicals.

Monitoring Methods

A wide range of sampling methods can be used. These include:

1. sampling pumps, with appropriate tubes and filters
2. colour tubes
3. passive sampling badges
4. direct reading instruments, for real-time readout of results
5. data logging instruments for collecting data over time
6. biological monitoring

1. Sampling Pumps with Tubes, Filters or Impingers

A sorbent tube (**Figure 1**) is a glass tube, usually containing two layers of a solid adsorbent. When air is actively pulled through tube, airborne chemicals are trapped by the first layer, with the second layer serving as a backup to indicate possible 'breakthrough' ie overloading of the first layer. The tube is securely capped after sampling and sent to the laboratory for analysis.

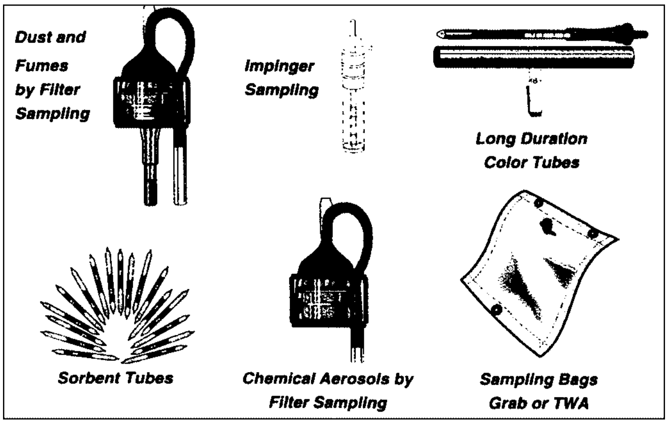

Figure 1 - Examples of sampling devices

Filters are used to collect particulate airborne hazards such as dusts, mists, aerosols and fumes. The air is actively pulled through a filter of a specific type, and which has a defined pore size. The analysis can be carried out using microscopy, gravimetry or by dissolving or extracting the filter and using an instrumental method such as ICP-MS or GC.

An impinger is a glass tube which is filled with a trapping solution which will chemically react with or physically dissolve the chemical of interest. A known volume of air is bubbled through the impinger which is then sealed and sent to the laboratory. Analysis may be by titration (for acids or bases), HPLC (eg for formaldehyde or isocyanates), ion chromatography (chloride, nitrate), etc.

The pump may be set up in the workplace on a bench, for example, or may be worn attached to the belt, or in a pocket, in which case a small, battery powered pump is used. The pump incorporates a flow meter, and often a timer, and is connected to a suitable tube, filter or impinger.

The pump is set up for a given time period, or volume of air, and the air from the workplace is drawn through the sampling device. At the end of the exposure period, the tube, filter or impinger is sealed and sent to the laboratory for analysis.

2. Colour tubes

The colorimetric devices have been in use for many years, perhaps the best known being Draeger Tubes. A hand pump is used to draw a known volume of air through the tube containing the crystals. The level of chemical in the air is indicated by the distance down the tube that the colour change moves. This is the same principle as the 'Blow into the bag' Breathalyser. This method is used, for example, for hydrogen sulfide, ammonia and chlorine exposure.

3. Passive Sampling Badges

These badges contain a thin layer of adsorbent, often charcoal. The air sample comes into contact with the adsorbent by diffusion. Badges are worn clipped on to the outside of the workers clothing, and the exposure times are varied according to what is being monitored. An example is given in **Figure 2**.

4. Direct Reading Devices

These electronic devices incorporate an electrochemical sensor to convert the concentration of chemical in the air into a reading on a meter or digital display. Among the uses of these devices is monitoring flammable gases, oxygen and carbon monoxide levels in mines and other enclosed spaces, sulphur gases in the air around factories, and hydrocarbons in vehicle exhausts.

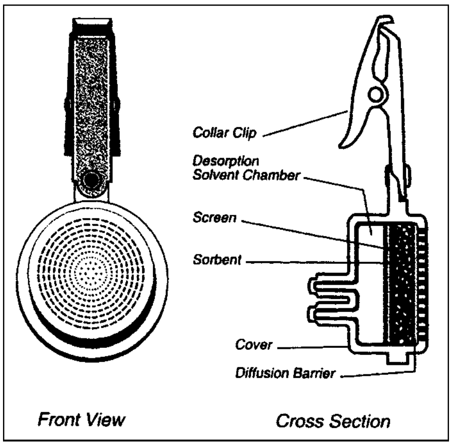

Figure 2 - A passive sampling badge

5. Data logging Instruments

Continuous measuring data loggers may be used to obtain a ‘picture’ of concentrations over a working day (or week, or longer).

They may be installed in a workplace to provide emergency warnings if gases reach a dangerous level, such as chlorine in a water treatment plant, or ammonia in a large coolstore. They may also be used to monitor the release of pollutants into the environment, as in sulphur gases from a factory chimney.

Data loggers usually monitor temperature and humidity, and gases such as carbon monoxide/dioxide, nitrogen oxide, nitric oxide and formaldehyde.

6. Biological monitoring

Biological monitoring involves collecting a sample of blood, urine, hair, or other tissue, and measuring the concentration of the chemical or a metabolite (something produced in the body from the chemical).

Examples include analysing for
- blood lead levels, for exposure to lead
- mandelic acid (a metabolite), for exposure to styrene
- cholinesterase (an enzyme), for exposure to pesticides

Analysis of samples

Samples obtained on badges, tubes, filters or impingers are sent to a laboratory for analysis. Depending on the nature of the chemicals to be determined, a wide range of techniques can be used. Examples include:
- gravimetry (weighing!) for dust
- titration, for acidic gases
- spectrometry, for ammonia
- ion selective electrode, for fluoride
- high performance liquid chromatography (HPLC), for resin monomers, formaldehyde
- ion chromatography, for acids
- gas chromatography (GC), for hydrocarbons, benzene, solvents
- gas chromatography-mass spectrometry (GC-MS), for pesticides

Use of Results

The results received from the laboratory can be used to calculate a variety of factors which are used to determine the degree of risk associated with a worker's exposure. Two commonly used terms are:

"STEL" (Short Term Exposure Limit)- This is the average exposure level over a short time interval, usually 15 minutes.

"TWA" (Time-Weighted Average, usually over 8 hours) -The average full shift exposure level. This is calculated by weighting the various concentrations throughout the workday with respect to time by using the following formula.

$$\text{TWA} = \frac{C_1T_1 + C_2T_2 + C_3T_3 \ldots}{8\text{hr}}$$

where TWA = Time-weighted average concentrations in ppm or mg/m^3.

C = concentration of contaminant during an incremental exposure time

T = the incremental exposure time

Acceptable levels for both the STEL and TWA are published in books and, often, in legislation. The latter means that, if these limits are exceeded, the employer may be taken to court.

Examples of both are shown in the **Table 1**.

Table 1 - Examples of STEL and TWA

Chemical	**STEL/ppm**	**TWA/ppm**
Benzene		5 (15 mg/m^3)
Methanol	250	200
Lead		<0.1 mg/m^3
Acetone		1000
Hydrogen sulfide	10 (10 minutes)	
Nicotine		0.5 mg/m^3
Formaldehyde	0.1	0.016
Hydrocarbons	440	85
Sulfur dioxide	5	2

References used

1. SKC Catalog, 1998/99, "The Essential Reference for Air Sampling" (ex Medtec, Wellington)
2. ESR, Lower Hutt, Information Pamphlets on Environmental and Occupational Health monitoring.

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