INTRODUCTION

By 1986, the National Institute for Occupational Safety and Health (NIOSH) had registered over 90,000 chemicals with some toxic effect. Since then, this number has increased 7–10% every year. Only about 10% of the chemicals used in commerce have undergone toxicity testing. Definitive biological monitoring data is available for less than 100 of these chemical compounds. In context of limiting exposure to agents that are associated with toxic effects, biological monitoring has been used with increasing frequency over recent years. This article, which is the first in a series of three, will discuss recent trends with particular attention to NIOSH programmes cross-referenced to the Hazardous Chemical Substances Regulations, 1995, issued under the South African Occupational Health and Safety Act (OHSA).

The primary goals of biological monitoring are:

• The prevention of disease by detecting meaningful exposure before the occurrence of a significant health effect.
• To assist the assessment of risk.
• To evaluate the effectiveness of environmental controls.
• Identifying agents associated with toxic effects (including mixtures containing such agents) in the occupational environment.

The fact that chemical agents do not discriminate between workers and non-workers in producing adverse health effects makes it of vital importance to identify the source of exposure and the toxicity. Adverse health effects may result from subsequent exposure to chemical agents in the close proximity to industry, a disposal site, contaminated water, food and air.

Biological monitoring should be viewed in total context of control and prevention of work-related exposures and diseases. Exposure to agents associated with toxic effects should be prevented directly.

Primary prevention can be most readily achieved through pre-market toxicology testing of the agents, the substitution of less hazardous substances, the installation of engineering controls and the use of personal protective equipment.

Biological monitoring can be used to help ensure that substantial exposure has not occurred, and therefore, it can be useful when primary prevention is not completely effective in controlling exposure to agents associated with toxic effects. This must however be managed well to ensure that no exposure to these agents is exceeding the exposure index for that situation as set by the health professional.

TERMINOLOGY

In the past, exposure to agents in the workplace has been evaluated by measuring concentration in ambient air and in the workers breathing zone, or by using existing personnel records. In recent years the human monitoring methods have been used with increasing frequency for the evaluation of workplace exposure. General measurement of the concentration of a chemical in ambient air, excludes the worker’s possible susceptibility to these chemicals. There are three terms used to describe human monitoring activities...
Medical screening is the administration of a medical test to individuals for the purpose of detecting organ dysfunction, before the disease process becomes manifest leading the individual to seek medical cure. Medical screening test may indicate that a disease is present or indicate a high probability of disease and the need for additional confirmation testing.

Medical surveillance is the systematic collection, analysis and evaluation of health data to identify problems or trends suggesting an adverse health effect or the need for further investigation or medical action.

Biological monitoring is normally done to determine exposure to hazardous chemicals, their metabolites, either in tissues, fluids, secreta, excreta, expired air or any combination of these, to determine exposures and health risks. These are then compared to an appropriate reference.

It is recognised that biological monitoring can address a continuum of endpoints, sometimes referred to as biochemical markers, ranging from those that can indicate recent agent uptake alone to early biological events. The early biological events are indicative of early possible exposure, which may be indicative of disease process and risk. Ongoing biological monitoring should be done until interpretation can be given with certainty of the exposure in question. Before an endpoint is used routinely to monitor workplace exposure, it must be demonstrated to predict exposure and pre-date the disease process. With the correct analytical methods available, biological monitoring of body fluids or tissue samples can be performed to evaluate the effectiveness of controls for minimising dermal exposure and percutaneous absorption. Biological monitoring should serve as an important addition to exposure monitoring and should be incorporated into an exposure assessment and monitoring standard when appropriate.

The usage of the term ‘biological monitoring’ and its relationship to environmental monitoring are consistent with the Biological Exposure Index published by the American Conference of Governmental Industrial Hygienists; the recommendations are summarised in a joint publication from NIOSH, the Occupational Safety and Health Administration (OSHA), the South African OHSA and Mine Health and Safety Act, and the Commission of European Communities’ medical screening and surveillance. They are designed to detect organ dysfunction, processes leading to disease or disability, or deteriorating trends in organ functions. When an adverse effect is reversible, biological monitoring presents the best opportunity for prevention, by being effective before any severe adverse health effect occurs.

**USE OF BIOLOGICAL MONITORING IN POLICY RECOMMENDATIONS**

The mandated responsibilities of government departments and specialist agency as NIOSH USA and HSE UK include the development of criteria to assure every employee has a safe and healthy working environment. These criteria are typically presented in documents or regulatory submissions in South Africa’s OHSA or the Mine Safety and Health Administration (MSHA) of the Department of Labour in the USA, or in special reports.

We recognise that the measurements of exposure to agents in breathing zone air does not assure that the worker is totally protected from adverse health effects from exposures in
the workplace. The actual body burden of the agent resulting from all routes of exposure is more directly related to potential adverse health effects.

Interaction of agents with other environmental and workplace agents and factors may also stimulate or inhibit its metabolism and elimination, and thus influence the toxicity of the agent to the worker. Consequently, the ambient air concentration of an agent is related to the body burden of the agent only under specified conditions. Agents’ metabolic rates, distribution rates, half-lives and elimination rates in humans are not always taken in consideration when setting up an agent risk profile.

A very important question is: “How much exposure is required to trigger medical surveillance or biological monitoring medical screening?” This question cannot be addressed adequately unless all the important routes of exposure for a specific agent or agents have been assessed. Inhalation, dermal and oral routes cannot always be assessed adequately by air measurements alone. However, biological monitoring can assess exposure uptake by all routes. Therefore general guidelines for medical surveillance medical screening will need to address the use of biological monitoring to supplement air monitoring under specific conditions.

CHALLENGES FOR PREVENTION OF OCCUPATIONAL DISEASE

The control and prevention of occupational disease face a number of challenges, some that biological monitoring will help to overcome and other that may become more challenging with the use of biological monitoring.

A major challenge for health professionals is how to determine an individual’s true exposure status in the absence of objective, defined, definitive evidence. Another major challenge facing health professionals involves assuming the ethical use of data and actions to remedy hazards. Some workers might be released from duty if their biological values are elevated. Such a practice might be justified on the basis of identifying susceptible workers. This, however, does not solve the problem and may result in discriminating actions against the ‘susceptible’ worker based on limited scientific evidence.

Additionally, ethical concerns are raised as to when individuals should be notified that they might be at risk of significant adverse health effects. This is very difficult when historical exposure data is not available. An example of this is manganese, as discussed in Occupational Health Southern Africa, Vol. 11, No. 3, May/June 2005.

Finally, and most important, but more difficult to address and resolve, is whether or not the legal and regulatory context is sufficiently developed for the prevention of occupational disease.

CONCLUSION

Biological monitoring should be viewed in the total context of prevention and control of work-related disease. Biological tools are valuable tools that can assess the biological exposure to agents associated with toxic effects before any significant health effect has occurred.

The next article will examine the relationship between external and internal doses of organic solvents.

REFERENCES