HEALTH & HYGIENE

LEARNING OUTCOME

Describe the processes for managing a worker's exposure to health hazards in the workplace.

ASSESSMENT CRITERIA

- Describe the role of at least three occupational health and safety professionals involved in the assessment, identification, evaluation, monitoring and control of work caused illness.
- Describe basic toxicological principles.
- Describe concepts in relation to the workplace exposure standard.
- Describe the type, effects and controls of at least three health hazards commonly encountered in the workplace.
- Describe at least two techniques used to monitor workplace exposure to health hazards.

REFERENCES

Managing Risks of Hazardous Chemicals in the Workplace 2013

Hazardous chemical information
http://hcis.safeworkaustralia.gov.au/ExposureStandards

WORKPLACE HEALTH AND HYGIENE

INTRODUCTION

Definitions

- Occupational health involves maintaining a state of well-being and freedom from occupationally related disease or injury.
- Occupational hygiene is described as the recognition, the identification, the evaluation and the control of situations involving workplace hazards.

Workplace Health Protection - Occupational Hygiene

Occupational hygiene involves anticipating and recognising potential health hazards in the workplace including:
- Chemical agents e.g. gases, vapours, solids, fibres, liquids, dusts, mists and fumes;
- Biological hazards; and
- Physical agents e.g. noise, vibration, heat, cold, lighting.

HEALTH HAZARDS IN THE WORKPLACE

Health hazards in the workplace includes chemical hazards, physical and biological agents.

Physical Agents

All workplaces encounter some agents of the physical environment which have potential to present health hazards at work. These hazards occur in all industries including agriculture, manufacturing, construction, transport and health industries. Adverse health effects can result from exposure to:

Noise	Absorbed through the ear. Some very low frequency (infrasound) and ultrasonic sounds are absorbed indirectly by the body.
Vibration	Received by the whole body or body parts, such as hands and arms, when in contact with vibrating plant. Plant includes machinery, vehicles, equipment, appliances, containers, implements and tools.
Light (radiation)	Visible, ultraviolet and infrared light (non-ionising radiation) and x-rays and gamma rays (ionising radiation) are types of electromagnetic radiation that can be harmful to the whole body. Lasers emit a concentrated beam of non-ionising radiation that is very damaging to eyes. Ionising radiation health standards are managed by Queensland Health and workplace exposure to non-ionising radiation is managed under the Work Health and Safety legislation.

Heat	Acts on the whole body. The heat load on a body can come from the external environment such as air temperature or hot objects, from internal heat produced by the body and from clothing.
Cold	Cold environments act on the whole body or extremities that may be in contact with cold.

Biological Agents

Some workers are subject to specific health hazards relating to the nature of their work with biological materials or from working in environments where micro-organisms may be present. These hazards may be related to existence of animals or plant materials, or sometimes the treatment of sick person. A few biological hazards exist more widely and affect members of the general working community. Some of the biological or microbiological hazards of workplaces include the following classes:

- Bacterial - Legionella, brucella, tuberculosis, Q Fever etc
- Fungal - Ineffective agents eg tinea
  Allergenic agents eg Aspergillus
- Viral - Hepatitis B, HIV (AIDS)

Chemical Agents

Chemicals may be present in the workplace as a hazardous chemical, intermediary or by-product of a work process, or a waste product. They can be found in plant and equipment, pipes, containers, vessels or in the workplace air for example diesel exhaust fumes from a truck.

Chemical agents may have health hazards, physical hazards or both. Manufacturers and importers are responsible for classifying hazardous chemicals according to the Globally Harmonised System of Classification and Labelling of Chemicals, called the GHS.

HAZARDOUS CHEMICALS AND HEALTH

Hazardous chemicals that can harm health may be stored, handled or generated in a workplace. Sometimes hazardous chemicals can be easily identified through a safety data sheet (SDS) or a label on a container. Other times a chemical may not have a label or an SDS for example where fumes are generated from an activity such as welding.

Hazardous chemicals may be found in a variety of forms including:

- solids
- dusts
- fumes
- liquids
- vapours
- mists
- gases

GHS pictogram for toxicity

GHS pictogram for Systemic health hazards

Types of health hazards

- Hazardous chemicals can harm health in different ways such as:

GHS pictogram for irritation and lower systemic health hazards

- Acute poisoning (acutely toxic) by inhalation, swallowing, or in contact with skin
- Skin corrosion or irritation
- Eye damage or irritation
- Allergy, asthma symptoms or breathing difficulties
- Allergic skin reaction
- Cancer, genetic, fertility or birth defects
- Organ damage, such as lungs, kidneys, nervous system, through a single exposure or repeated exposure
- Toxic by swallowing and entering airways (aspiration)

Adverse health effects can be acute (short term) or chronic (long term). Acute health effects include poisoning, skin corrosion, headaches, nausea or vomiting, while chronic health effects include asthma, dermatitis, nerve damage or cancer.

Routes of Entry

Hazardous chemicals can act directly on the skin such as corrosion or irritation. Chemicals can also harm health by entering the body. There are four major ways chemicals can enter, these are called routes of entry:

- **Inhalation -** breathing in chemicals is the MAJOR route of entry in the work environment. This route requires the substance to be in the air as a dust, fume, vapour, mist or gas. These airborne particles may be so small they can't be seen by the naked eye and will stay suspended in the air for many hours.

  Always be on the lookout for a situation where there is the potential for the generation of an airborne contaminant. The quality of air in the workplace is important. On average, a person can inhale more three thousand litres of air over an 8-hour day working day. In conditions of hard physical work, this may increase to ten thousand litres. Workers need to breathe continuously. Remember things that cannot be seen may be just as harmful as those that can be seen.

- **Skin Contact -** contact with the skin and eyes may be as a result of direct contact from handling a substance, e.g. placing bare hands in a solvent tank, or indirectly from airborne contaminants. Skin exposure is the second most important route of entry in the work environment.

  Always be on the lookout for situations where workers are directly handling hazardous chemicals with bare skin.

- **Ingestion -** swallowing of hazardous chemicals is usually a minor route of entry in the work environment. However for some chemicals, such as lead, ingestion can add significantly to a workers exposure. For example, where lead is released to the air from a work process, it will settle onto surfaces handled by workers who may then handle food with contaminated hands and accidentally swallow lead particles. As well as using adequate measures to control exposure, good personal hygiene is required.

- **Injection -** injection of substances into the body can occur by such things as standing on nails, airless spray guns, hydraulics and compressed air. Injection injuries that involve chemicals may appear minor when they happen but the toxic effects can be very serious and not immediately obvious.

Common Workplace Hazardous Chemicals

A WHSO can be expected to deal with the use of chemical hazards in workplaces. Common hazardous chemicals found in workplaces include:

- organic solvents
- adhesives
- paints and paint thinners
- dusts such as asbestos and respirable crystalline silica
- heavy metals such as lead, cadmium and mercury
- welding fumes
- acids, alkalis and other corrosives
- pesticides
- gases such as ammonia and chlorine
- cement

How to Manage the Risk Associated with Hazardous Chemicals

Regulation section 351: A person conducting a business or undertaking must manage risks associated with using, handling, generating or storing of hazardous chemicals at a workplace.

Regulation sections 32-38: In order to manage risk under the Regulation, a duty holder must:

a) identify reasonably foreseeable hazards that could give rise to the risk
b) eliminate the risk so far as is reasonably practicable
c) if it is not reasonably practicable to eliminate the risk – minimise the risk so far as is reasonably practicable by implementing control measures in accordance with the hierarchy of risk control
d) maintain the implemented control measure so that it remains effective
e) review, and if necessary revise all risk control measures so as to maintain, so far as is reasonably practicable, a work environment that is without risks to health and safety.

The *Managing Risks of Hazardous Chemicals in the Workplace Code of Practice 2018* provides guidance on how to manage the risks associated with hazardous chemicals in the workplace by following a systematic process that involves:

- identifying hazards
- if necessary, assessing the risks associated with these hazards
- eliminating or minimising the risks by implementing and maintaining control measures
- reviewing control measures to ensure they are effective.

When managing the risks, regard must be had to the following factors:

- the hazardous properties of the hazardous chemical
- any potentially hazardous reaction (chemical or physical) between the hazardous chemical and another substance or mixture, including a substance that may be generated by the reaction
- the nature of the work to be carried out with the hazardous chemical
- any structure, plant or system of work that:
  - is used in the use, handling, generation or storage of the hazardous chemical
  - could interact with the hazardous chemical at the workplace.

As well as the *Managing Risks of Hazardous Chemicals in the Workplace Code of Practice 2018* there are other sources of information on risk assessments for hazardous chemicals, such as *Simplified Occupational Hygiene Risk Management Strategies (Australian Institute of Occupational Hygienists)*. The WHSO may need to consult with an occupational hygienist when carrying out risk assessments for hazardous chemicals.

ASSESSING HEALTH RISKS

The terms ‘hazard’ and ‘risk’ have quite distinct meanings.

Hazard relates to the recognised toxicology of the substance. That is, hazard is the ‘potential’ of a chemical to cause harm. Thus, when the term hazardous chemical is used, it means a substance which has the potential, by way of its toxicity, to cause harm, under the appropriate conditions.

There is a very valuable quote to remember when thinking about the risk from hazardous chemicals:

> “All substances are poisons; there is none which is not a poison.
> The right dose differentiates a poison and a remedy.”
> *(Paracelsus 1493 - 1541)*

In other words, all substances have hazardous properties, but there is a wide variation in toxicity between different substances. Some substances have very low toxicity, for example drinking extremely high quantities of water can result in water toxaemia which is fatal. Highly toxic substances can be fatal in very low quantities for example as little as 1 gram could kill an adult. One classification of substances uses the following terms:

- super toxic
- extremely toxic
- very toxic
- moderately toxic
- slightly toxic
- practically non-toxic

Risk relates to the ‘likelihood’ of an adverse effect occurring in a particular situation and the ‘consequence’ is the health impact if an event occurs. For a hazardous chemical to pose a risk in the workplace, the worker must be exposed to a sufficiently large amount of the substance.

In essence, hazard relates to the recognised toxicity of a substance, whereas risk relates to the method of use of the substance.

BASIC TOXICOLOGY

Definition

Toxicology is the study and description of the adverse effects of chemical and physical agents on living organisms. By having knowledge of basic toxicology concepts, the WHSO will

- be able to recognise health hazards in the workplace;
- better understand exposure guidelines or standards; and
- more readily determine the necessary control measures for a particular hazard.

THE CONCEPT OF OCCUPATIONAL DISEASE

Occupational safety can generally be said to deal with accidents and their prevention, whilst occupational health deals with occupational disease and its prevention.

There are three important differences between injury and disease: Time, Dose and Damage.

These are explained as follows:-

The factor of TIME

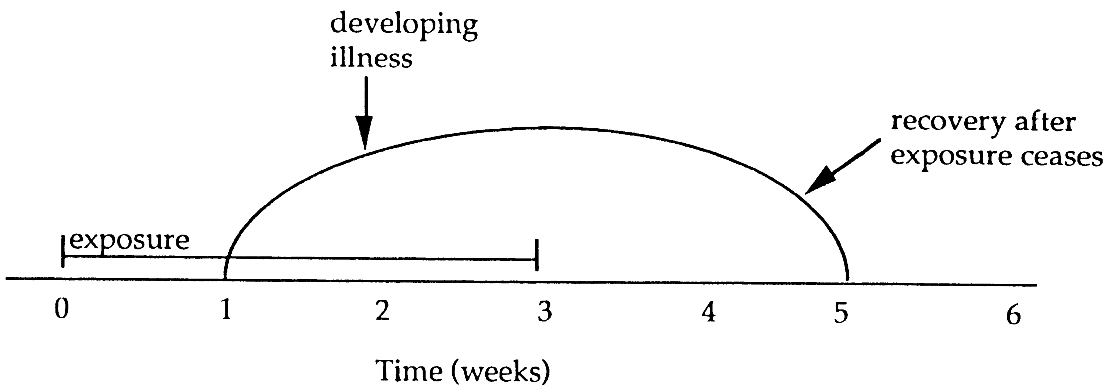
Accidents and the resulting injury occur at virtually the same point in time and result from a single incident. Hence the link between *cause* and *effect* is obvious.

Occupational diseases mostly, but not always, require multiple exposures to the causative agent over a variable period of time.

Disease may take from minutes to many years to develop. Consider carbon monoxide poisoning and noise induced hearing loss.

So, the time factor is very variable. Look at these examples:-

Example 1 - Exposure to high levels of solvent vapour.



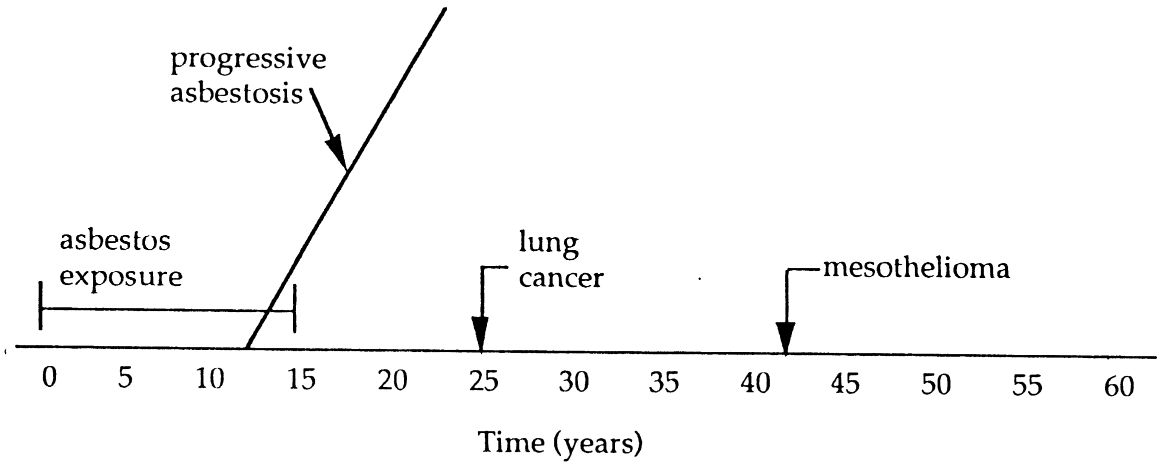
Example 2 - Asbestos related disease.

There are three diseases associated with heavy exposure to asbestos - each has a different time factor.

Asbestosis - A slowly developing non-malignant disease in which the lungs are scarred and function gradually deteriorates.

Lung Cancer - A cancer which can occur 20 or more years after heavy exposure. It is much more common in asbestos workers who smoke.

Mesothelioma - A rare cancer of the membrane covering the outer surface of the lung - especially associated with exposure to blue asbestos. It can occur up to 50 years after moderate exposure.



The factor of DAMAGE to tissue

An accident may injure many tissues but only where the energy of the accident is applied, eg. a part of the body such as the head or the arm, etc.

With disease, the tissue affected may be remote from where the causative agent is applied. For example, inhaling solvent vapours through the lung can produce effects on the brain such as headaches, drowsiness and so on.

As well, there may be small changes taking place to the body's function which are not obvious - there may be no obvious illness and often the worker will be completely unaware of these subtle effects.

For example, small amounts of lead produce changes in the blood chemistry even though the person remains quite well.

The DOSE factor

The term dose means the amount of a substance which is absorbed. In particular, it depends on:

- concentration of exposure; and
- duration of exposure

With accidents, a single event causes the injury. With disease causing agents, whether chemical or physical in nature, multiple exposures, often over many years, can occur with safety, provided the safe Dose for that substance is not exceeded. The safe dose will vary depending on the substance. It will be very small for highly toxic substances and large for those with a low toxicity.

Disease occurs only when the safe dose is exceeded. This may be a single event but more commonly only occurs as an additive effect of multiple exposures over time.

From this, it can be seen that for occupational diseases, the link between cause and effect if usually not obvious. Therefore to prevent disease or detect minor change early before it makes the worker ill, it is essential to have knowledge of any conditions in the workplace which make it a risk to health.

EXPOSURE IN THE WORKPLACE

Detection and prevention of disease requires an understanding of a wide array of work situations and knowledge of the effects that various hazardous agents can have on workers. It is necessary to have knowledge of:-

- which agents in use at the workplace are hazardous;
- how much exposure is hazardous;
- what procedures are necessary to monitor the workplace and worker exposure; and
- how exposure can be controlled.

Only when armed with this information can those responsible for occupational health take steps to prevent work-related illness.

The Importance of Dose

Before any hazardous chemical can exert an adverse effect, a person must be exposed to the substance and the level or dose absorbed must be high enough to produce its potential adverse effect. For very toxic substances, relatively small doses will produce adverse effects and conversely, in the case of low toxicity substances, relatively large doses are required. But, always remember 'Paracelsus theory'.

Whenever a hazardous chemical is used in the workplace, it is necessary to make an assessment of the risk associated with that use. In other words, an assessment of the likely dose of exposure is required and if it is concluded that the risk is high, then immediate corrective action is required. On the other hand, if the risk is judged to be low, or negligible, then no particular action will be necessary other than on-going monitoring of the risk.

In the work environment, three types of exposure to hazardous chemicals can be predicted:

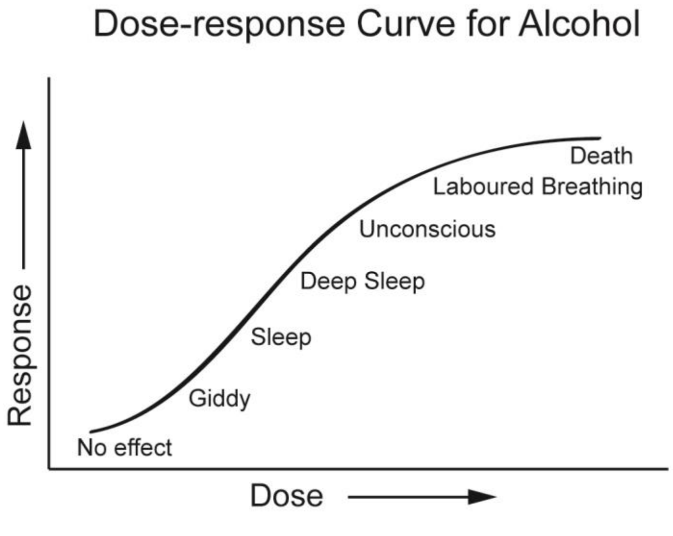
- **Regular exposure** within recommended standards - this represents a low risk situation and adverse effects are unlikely.

- **Sudden, short lasting, gross over-exposure,** e.g. entering a confined space which is highly contaminated by organic solvent vapour. This represents a high risk situation with potentially drastic acute effects. Such events are uncommon, but they must be avoided.

- **Repeated exposure** to a hazardous chemical but at a level moderately above the recommended standard, e.g. spray painting for 6 hours per day, but without the use of an effective booth or respiratory protective equipment. If the hazardous chemical has the potential for chronic effects, e.g. chronic, solvent neurotoxicity, then this situation represents a high risk situation, but with effects of insidious onset. This type of situation is very common in the work environment and is also in need of particular preventive action.

For many hazardous chemicals, there are adequate toxicology data available to determine the level of exposure which can be regarded as acceptable on the basis of occupational exposure, i.e. 8 hours per day, 40 hours per week for a working lifetime. If exposure is kept within those recommended levels, then significant, adverse effects are largely unlikely.

The dose-response curve for a particular substance becomes the basis on which an acceptable level of exposure can be determined. The following graph depicts the concept of a dose-response curve. (The graph is NOT drawn to scale, but merely demonstrates the concept).



As the dose increases, the adverse effect increases from nil to insignificant adaptational changes to disease and in the extreme, death.

TOXIC EFFECTS OF HAZARDOUS CHEMICALS

Hazardous chemicals can adversely affect the body in many different ways. Many substances can cause a range of effects with a particular effect depending on the level of exposure.

There are a number of ways to categorise the adverse effects of a hazardous chemical. These include:

- local and systemic effects
- acute and chronic effects
- interactive

Local effects are adverse effects on the particular tissue to which the substance is applied. For example, corrosives injure the skin or eyes if the material comes into contact with that tissue. Regular skin contact with organic solvents can cause defatting of the skin and the eventual development of dermatitis. The inhalation of acid gases such as ammonia or chlorine causes intense irritation of the tissues of the respiratory tract.

Systemic effects, on the other hand, refer to adverse effects on a system of the body. For example, excessive absorption of lead by inhalation or ingestion can cause lead poisoning, but the symptoms relate to the nervous system, blood and kidneys. Excessive absorption of pesticide by inhalation, ingestion or skin contact can affect many systems of the body, in particular the
nervous system. In other words, systematic effects relate to symptoms which are distal to the point of entry of the hazardous chemical into the body.

Acute effect means adverse reactions which occur very soon after or during exposure to a hazardous chemical. Examples include:

- exposure to irritant gases such as ammonia or chlorine causes immediate irritation to the
  eyes, nose, throat and airways of the lungs;
- absorption of an excessive amount of pesticide causes acute poisoning within a few hours or less;
- ‘arc eyes’ develops within a few hours of intense exposure to UV (ultraviolet) radiation during welding.

Acute effects can be categorised as follows:

- Irritant effects on the skin or mucous membranes, eg. solvents, corrosives, acid gasses and welding fumes.
- acute poisoning with systemic symptoms, eg. acute lead poisoning, acute organic solvent overexposure, pesticide poisoning.
- reproductive effects such as teratogenesis (birth malformations) or miscarriage from the acute effect of a substance on the developing foetus.

Chronic effect means that the adverse effects are prolonged, if not permanent. Onset may occur soon after exposure or be delayed for many years. Examples include:

- chronic renal (kidney) failure from lead or cadmium, fibrosis of lungs by asbestos or free silica; chronic dermatitis from a skin irritant.
- carcinogenic effects of the development of tumours / cancer, e.g. lung cancer and mesothelioma following asbestos exposure; bladder cancer following exposure to aniline dyes; skin cancer from UV radiation.
- reproductive effects such as permanent damage to DNA structure (genetic material) of sperm or ova and reduced fertility due to suppression of sperm production.

Interactive effect means the interactive or additive effects of different exposures. This incorporates the way in which chemicals may interact with each other or may add to one another to increase or magnify individual responses to differing chemicals.

OCCUPATIONAL HYGIENE

The Concept of Workplace Exposure Standards

As part of your responsibilities in a workplace which is using or producing hazardous chemicals, one of the questions which needs to be uppermost in your mind is . . . “How do I judge whether this workplace is safe and healthy?”

The thrust of the legislation and regulations is to maintain some standard in order to ensure healthy conditions when handling or producing hazardous chemicals in the workplace. What is that standard?

In fact, a number of different types of standards exist. Each depends on whether the hazard is one which is inhaled, or whether it affects other sensory organs (eyes or ears), or whether it affects us by radiation or vibration. All these standards accept the point of view that the workplace will inevitably expose its workers in some way but that, in general, the body is able to cope with limited exposure to hazardous chemicals or hazardous environments.

Workplace exposure standards (WES) for atmospheric contaminants in the occupational environment are produced nationally by Safe Work Australia and can be accessed at http://hcis.safeworkaustralia.gov.au/ExposureStandards.

Workplace Exposures Standards relate to how much of a hazardous material a worker can be exposed to during his or her working day without suffering any adverse effect.

The following list gives an indication of the kinds of materials you will encounter to which frequent reference to workplace exposure standards will be required.

Organic chemicals	eg. chloroform, hexane, toluene
Inorganic dusts	silica, asbestos, talc
Pesticides	parquet, dichlorvos
Heavy metal dusts	lead, chromium, zinc oxide
Heavy metal vapour	mercury
Organic dusts	wood, wheat
Gases	Ethylene oxide, carbon monoxide
Acid gases	Hydrogen chloride, chlorine, cyanide

Workplace exposure standards in Australia cover approximately 700 chemicals. A workplace exposure standard for a particular chemical sets out the legal concentration limit of that chemical that must not be exceeded.

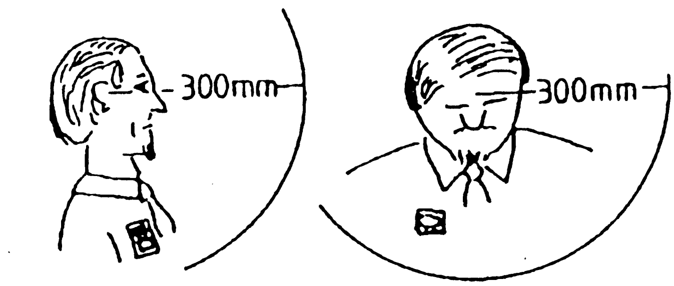
Workplace exposure standards are not intended to represent acceptable exposure levels for workers. They are simply the maximum upper limit prescribed by legislation.

Workplace exposure standards do not identify a dividing line between a healthy or unhealthy working environment. Everyone is different, and this means that some people might experience adverse health effects below the exposure standard.

The Concept of the Breathing Zone

A worker's breathing zone is described by the hemisphere of 300 mm radius, extending in front of the face and measured from the midpoint of an imaginary line joining the ears.

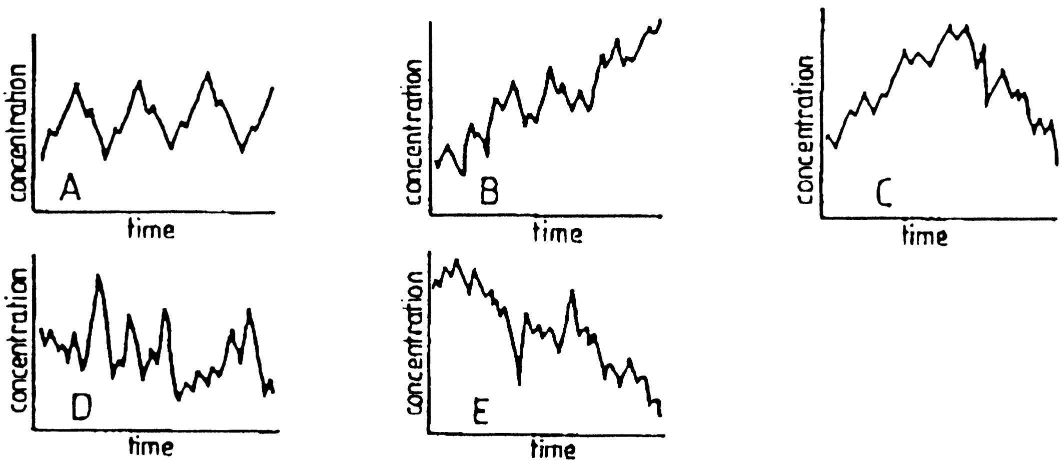
Now, if this is all a bit hard to imagine, it is the zone generally about the face and upper chest.



The Exposure Standard can be of three forms:

Time Weighted Average (TWA): the average airborne concentration of a particular substances when calculated over a normal 8-hour workday, for a 5 day working week.

If we were to plot the concentration of a hazardous chemical to which a worker was exposed during a day, it would typically look like the following:



So, we see that a single measurement at one point of time will not adequately determine Time Weighted Average exposure to the hazardous material. Therefore:

- an average of a number of readings needs to be obtained, or
- you need samples for the whole time and get an average figure.

Peak: the maximum or peak airborne concentration of a particular substance determined over the shortest analytically practicable period of time, which does not exceed 15 minutes.

Short Term Exposure Limit: a 15-minute TWA exposure which should not be exceeded at any time during a working day even if the 8 hour TWA average is within the TWA exposure standard. Exposures at the STEL should not be longer than 15 minutes and should not be repeated more than 4 times a day. There should be at least 60 minutes between successive exposures at the STEL.

Peak Limitations are sometimes referred to for materials which induce acute effects after relatively brief exposure to high concentrations. In order that such effects do not occur, a PEAK limitation is recommended for the material. Typically peak limitations will be found for corrosives such as acids or acid gases.

From these definitions, we see that:

- the exposure standards are not intended to prevent workers completely from being exposed to hazardous chemicals in the workplace
- exposure standards are not 'No Effect' levels for a whole host of reasons, but they can be used confidently as Guidelines both for:
    - assessing the hygiene of any workplace with respect to any hazardous material in question.
    - providing a workplace which will not lead to occupational ill health.

WARNING

One important point is to remember that Workplace Exposure Standards are guidelines and only guidelines. They do not differentiate between safe and unsafe levels and occasionally they do not apply to all people.

WES will not be adequate for everyone.

- General biological variability and heredity are factors. Not all workers will develop symptoms at the same concentration.
- There are some people who have metabolic disorders which prevent them from detoxifying hazardous chemicals such as carbon monoxide.
- Exposure to combinations of materials may have an additive effect or multiplicative (synergistic) effect.
- Persons allergic to a material cannot be exposed to the material at concentrations often one-tenth or even one-hundredth the WES without suffering serious effects.
- Workers may have a relatively benign or non-disabling form of disease but any further cumulative exposure could lead to onset of a disabling or fatal disease e.g. silicosis.
- Habits of workers. Smoking and alcohol consumption affect the extent which workers are able to cope with exposure. Other examples are alcohol and solvents, smoking and asbestos exposure.

- Gender and reproductive status. For example, risks from exposure to lead are quite different for men and for women. The present WES might protect men well enough but may well not protect pregnant women from spontaneous abortions. Foetuses are at considerable risk where grown men are not.

Some examples of exposure standards for hazardous chemicals

Four commonly encountered hazardous chemicals, indicating different ways the standards are expressed:

SUBSTANCE	WES - TWA
XYLENE	100 parts per million
QUARTZ	0.1 mg/cubic m (respirable fraction)
CROCIDOLITE (blue asbestos)	0.1 fibres/mL
LEAD (inorganic dust and fumes as Pb)	0.15 mg/cubic m

There are four important points to note:

- the chemical xylene, used as common solvent in printing and spray painting, has its units of measurement in parts per million which is a volume of the solvent per volume of air.
- the quartz dust refers to a ‘respirable’ fraction of the dust and is referred to as the weight per volume of air (cubic metres of air)
- the blue asbestos refers to the number of fibres per volume of air (millilitres or air).
- the lead standard refers to particulate lead which is only one of the industrially found forms of lead.

There are some other points of information which are available from the exposure standard tables:

- a skin notation may be given for materials where skin absorption is important.
- some substances are classified as carcinogens.
- some peak limitations are specified for irritating agents.
- for some materials, a short term exposure limit (STEL) is given.

TYPES, HEALTH EFFECTS AND CONTROL OF COMMON WORKPLACE HAZARDOUS CHEMICALS

DUSTS

Among the oldest recognised occupational diseases are those caused by excessive exposure to dust. This history of ‘dust diseases’ goes back thousands of years to the time when Man first began mining operations.

In the modern workplace, there are many hazardous chemicals which exist in dust form and which can pose a serious risk to health if exposure to the dust is not adequately controlled.

Inhalation of Dusts

One definition of a dust is an airborne solid particle ranging in size from 0.1-25 micrometers. One micrometer is one millionth of a metre or one thousandth of a millimetre.

Dusts do not diffuse in air as do gases and vapours. Being solid particles, they settle under the influence of gravity. However, particles greater than about 25 micrometers in diameter tend to settle quickly under the force of gravity and thus, they present a low risk of inhalation. On the other hand, smaller particles remain airborne for prolonged periods as the force of gravity is counteracted by air currents. Thus, such dusts can be inhaled easily. The major problem posed by a dust is that it can be inhaled into the respiratory tract. The respiratory tract comprises a series of air passages of gradually decreasing size extending from the mouth and nose and terminating at the alveoli (air sacs). Air is inhaled through the mouth/nose and travels through the various passages. At the alveolar level, Oxygen passes from the inhaled air through the lining of the alveolar wall and into the blood.

Simultaneously, carbon dioxide passes from the blood through the alveolar wall and into the alveolar passage from which it is exhaled. This is the basic function of the lungs, namely the absorption of oxygen which is essential for life and the removal of carbon dioxide which is a waste product of metabolism. This process is termed gas transfer. If the inhaled air contains a dust, it can also be inhaled into the various air passages. The distance to which the dust will travel through the air passages depends on a number of factors, particularly the size, shape and density of the dust particle.

As the smallest air passages of the lungs are only about 7 micrometers in diameter, only dust particles which are smaller than that size can pass through them. Also, as the air passages are of gradually decreasing diameter, this means that the larger particles tend to be deposited in the larger air passages, whereas the smaller particles tend to be deposited in the smaller air passages.

As a general rule:

- most particles which are larger than 15 micrometers in diameter are deposited in the nose and throat.
- particles in the 10-15 micrometer range are deposited in the tracheobronchial tree (larger air passages down to about the 10-15th branches).
- particles in the 0.5-5.0 micrometer range are deposited in the alveoli and respiratory and terminal bronchioles.
- particles less than about 0.1 micrometers tend not to be deposited.

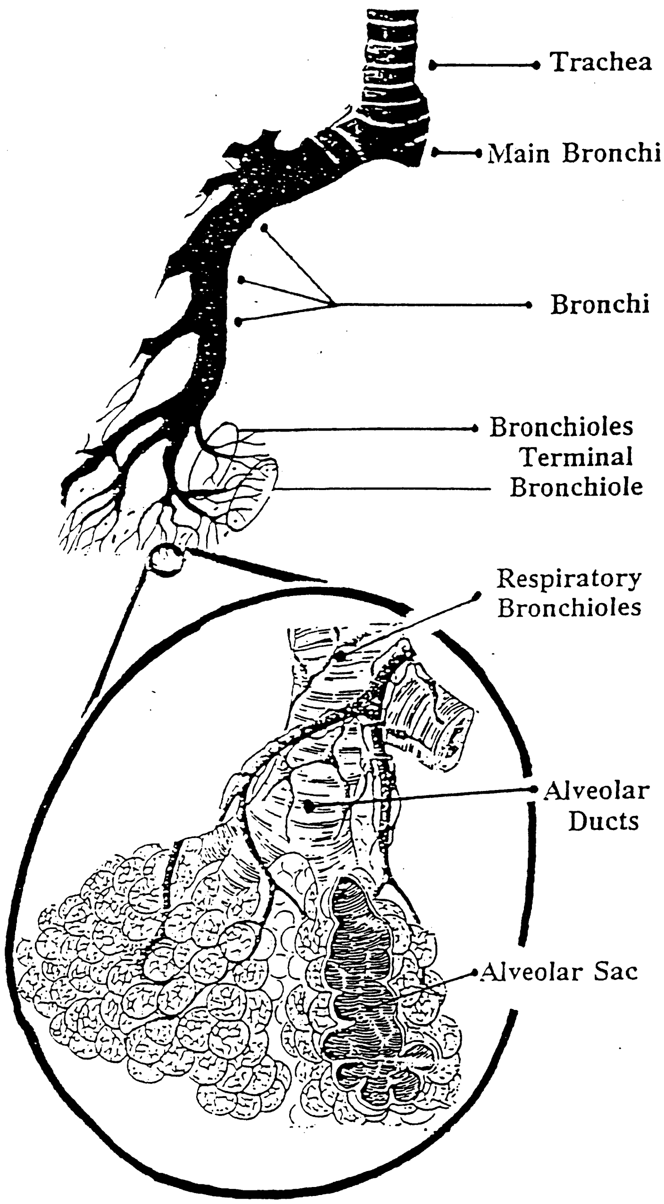
All dust which is able to be inhaled is termed INSPIRABLE DUST. That component which has the potential to reach the alveoli, i.e. 0.5 - 5.0 micrometers (approximately) is termed RESPIRABLE DUST, and it is this type of dust which is often the greatest hazard.

Once a dust is inhaled and deposited in the lungs or upper airways, there are a number of mechanisms available for its removal. These are:

- the mucociliary transport system - all the air passages down to the terminal bronchioles are lined by cells which have hair-like projections called cilia. There are also other cells/glands which produce mucous. Dust particles are trapped in this mucous and the wave-like beating of the cilia transports the dust-laden mucous to the mouth for swallowing or expectoration.
- the cough reflex also assists in removing dust and mucous from the air passages

- macrophages - many particles that reach the alveolar level are engulfed by scavenger cells called macrophages and removed from the lungs via the lymph system.

On the whole, clearance of dust by the bronchial (mucociliary and cough) and alveolar (macrophage) systems is efficient. When the clearance systems are overwhelmed by excessive dust exposure, adverse effects become more likely.



Classification of Dusts

One method of classifying dusts is based on the potential adverse effect of the dust.

- **Fibrogenic dusts** - dusts which can cause scar tissue (fibrosis) to develop in the lungs. This fibrosis 'stiffens' the lungs and can cause a reduction in lung function and decreased transfer of oxygen and carbon dioxide. Only respirable fibrogenic dusts can cause fibrosis to develop. Exposure to non-respirable fibrogenic dust does not pose this hazard.

  Fibrogenic dusts include:-

  - asbestos (causing asbestosis)
  - quartz (causing silicosis)

- **Toxic dusts -** a dust which can be absorbed into the blood system via the lungs and then cause systemic poisoning. Highly irritant dusts can also be regarded as toxic dusts.

  While respirable toxic dusts pose the greater hazard, non-respirable toxic dusts are also a hazard. Examples of toxic dusts are:
  - pesticide dust
  - metal dust, e.g. lead
  - extreme irritants, e.g. sodium metabisulphite

- **Allergenic dusts -** a dust which can cause a hypersensitivity (allergic) reaction such as hay fever or more serious lung diseases such as asthma or extrinsic allergic alveolitis. Examples include:
  - some wood dusts, e.g. western red cedar
  - grain dust
  - cotton bract dust
  - pollens
  - fungal spores

- **Carcinogenic dusts -** a dust which can induce cancer. The classic example is asbestos.

- **Nuisance dusts -** dusts which have no known adverse effect other than transient irritation of the respiratory tract. These dusts do not fall clearly into any of the other categories. Examples are:-

  - synthetic mineral fibres (possible carcinogen)
  - chalk dust
  - paper dust

GASES

In the workplace, the air can become contaminated by gases used in or formed as a by-product of the process. It is the aim of this Section to provide the Health and Safety Adviser with an understanding of the importance of toxic gases as an occupational health hazard.

Route of Entry of Gases

As for any airborne contaminant, inhalation is the main route of entry of toxic gases. Following exposure to a toxic gas the onset of symptoms can be rapid and in some cases, death may occur within minutes.

Classification of Hazardous Gases

For the purposes of occupational health and hygiene, gases can be classified into three groups.

- Irritant
- Asphyxiants
- Miscellaneous

Irritant Gases

Irritant gases are those which cause inflammation of the tissues to which they are exposed. This may range from simple discomfort of the eyes and upper respiratory tract to potentially fatal damage to vital lung tissue.

Irritant gases vary in their major site of action:

- Those affecting predominantly the eyes and upper respiratory tract, i.e. pharynx, larynx and larger airways.
-
- Those acting primarily upon the smaller respiratory passages and tissue involved in gas transfer.

These differences are due to variations in solubility among gases. As the respiratory tract is lined with moist tissue, highly soluble gases will act upon surfaces they first encounter, while less soluble gases will travel further down the respiratory tract before exerting their effect.

High Solubility Irritant Gases:
Cause severe burning, inflammation and irritation of the eyes, the pharynx and the upper respiratory tract. Examples:- Ammonia, chlorine, formaldehyde.

Low Solubility Irritant Gases:
Damage the lower levels of the lungs ie ozone can cause pulmonary oedema which may be fatal.
Examples:- Ozone, Nitrogen Oxide and Phosgene

Asphyxiants

Asphyxiants are gases which interfere with the uptake, transport or use of Oxygen by the body. They may be sub-divided into two groups.

- **Simple Asphyxiants** - these are gases that have little direct physiological effect but merely displace oxygen from inspired air. Thus, less oxygen is available for uptake by the lungs. They are only hazardous in high concentrations such as may occur in confined spaces. Common examples are - Methane, Carbon Dioxide, Nitrogen, Hydrogen, Helium and Argon.

- **Chemical Asphyxiants** - these are gases which interfere with the transport of oxygen by the blood or the use of oxygen by tissues. Low concentrations can be very toxic. Common examples are Carbon Monoxide and Hydrogen Cyanide.

Miscellaneous

Many toxic gases do not fit solely into the above categories. These include the fumigants such as methyl bromide, phosphine, and ethylene oxide which affect a range of tissues. Other examples are arsine and stibine which may be liberated when acids react on arsenic and antimony compounds respectively. This may be a hazard in metal ore treatment processes.

SOLVENTS

The term ‘organic’ describes the class of chemical compounds whose structure is based on carbon atoms. The term ‘Organic Solvents’ is used to cover a number of chemically dissimilar groups which are considered together because they share many properties. Organic solvents are found in virtually every workplace - from trichlorethane in office corrective fluid to major industrial applications such as degreasing tanks. Most glues, paints, cleaning and degreasing compounds found in both the home and the workplace contain this group of chemicals. As a result, it is common for people to be exposed to these compounds in the workplace.

The health effects resulting from exposure to organic solvents can be classified into two groups -

- Health effects common to all organic solvents
- Additional health effects from specific solvents

Health Effects Common to All Organic Solvents

Local Effects

As discussed, these are effects on the tissue to which the solvent or its vapour is applied. Particularly, we think of the eyes, the upper respiratory tract and the skin.

Eyes and Upper Respiratory Tract

All the organic solvents will cause severe irritation if the liquid splashes into the eyes. Some will cause serious eye damage.

Prevention - Where solvents are handled in large volumes, fixed shields should be built into the system.

Alternatively, personnel can wear personal protective face shields or goggles. Where solvent splashes are possible, an emergency eye wash station should be installed as near as possible to the solvent area.

Most organic solvents evaporate readily and produce high vapour levels in the air. This occurs especially where solvents are heated or where there are large surface areas newly painted or sprayed with glue. These vapours can cause irritation of the eyes and upper respiratory tract. Significant irritation of the respiratory tract will cause people to cough.

Prevention - Irritation of the eyes and respiratory tract from solvent vapour can be prevented by doing one or more of the following -

- ventilate the area well with fresh air; or
- exhaust the solvent vapour from the area; or
- provide respiratory protection for the operator.

A suitable respirator for high solvent vapour areas is a full-face respirator which will protect the eyes as well as the respiratory system. Such respirators use either canisters to absorb the solvent vapour or alternatively are supplied with fresh air from a compressed air source.

If employees complain of irritant effects from solvent vapours, it should be an indication to management that the levels of solvent vapour are excessive and control measures are needed. These effects are a warning that more serious systemic effects might occur.

Skin

All organic solvents are effective in dissolving oil. It is this property that makes them hazardous to skin. It is important to think of the skin as a living, breathing organ. It is not just a sheet of material to hold us together. The effects of solvents on skin can be both acute and chronic.

Systemic Effects

As discussed, these effects occur where a solvent is absorbed into the body and effects one or more of the body's systems. In the workplace, inhalation is the most important route of entry of solvent vapour into the body. The lung is an efficient absorbing surface and entry into the bloodstream delivers the solvent to the body organs within seconds.

The major systemic effect of organic solvents is their effect on the central nervous system (brain).

- At low levels, there can be headache, dizziness, drowsiness, nausea and difficulty in thinking clearly.
- At moderate levels of solvent vapour the person can appear drunk, i.e. they have unusual behaviour, they become silly or aggressive, their thinking is blurred and they may have a staggering gait.
- At extreme concentrations of solvent vapour, which can occur in confined spaces, the victim may become unconscious and if left in the solvent vapour may die when the respiratory system fails and the person stops breathing.

Most people affected by solvent vapours will recover quickly over a few hours if removed from further exposure. Sometimes, after a heavy exposure, it will take several days to recover, since some solvents have to be broken down by the body and their excretion is delayed.

Prevention - Good ventilation of the workplace is the key to prevention. Do one or more of these to prevent excessive exposure:-

- Ventilate the area well with fresh air;
- Exhaust the solvent vapour out of the area;
- Provide respiratory protection for the operator. For low concentrations, a half-face respirator fitted with an organic vapour cartridge will suffice. For higher concentrations or where there is eye irritation, a full face respirator fitted with an organic vapour canister is necessary.

In extreme concentrations such as can occur in confined spaces, a respirator supplied by compressed air is essential.

CHRONIC EFFECTS OF SOLVENT EXPOSURE

In recent times it has become evident that repeated exposure to high levels of solvent vapour can produce long-term effects on the brain in some people. These are classified as mild or moderate or severe. The severe form is more common in solvent abusers (e.g. glue and petrol sniffers) and is rarely seen in the workplace.

The mild and moderate forms can be seen as irritability, loss of interest in daily activities, depression and sometimes loss of memory. Such effects can occur in people whose occupations expose them to high levels of solvent vapour such as spray painters, fibreglass workers and dry cleaners. It is often difficult for doctors to decide if such effects are work-related or naturally occurring.

Acute Effects

Many solvents are irritating to the skin, particularly the delicate skin on the inside of the arms and various other parts of the body. Irritated skin will become reddened, itchy and sometimes painful.

Chronic Effects

These largely occur because the solvent washes the skin oils away causing drying and hardening of skin which may eventually become cracked. A disabling skin rash can result. This is called Industrial Dermatitis.

Prevention - Where hands are regularly in contact with solvent, the work should be mechanised as much as possible. Even simple mechanical devices such as wire hooks or tongs to dip parts in degreasing solvents will help. In addition, the worker should wear protective gloves which must be made from chemically resistant material.

Industries with regular skin problems should consider a proper skin care program. Solvent industries are not the only ones where this is relevant. Personnel required to handle concrete, cement, epoxies and other irritant chemicals frequently have skin problems and the same preventive efforts should be taken in these cases. The basic points in a skin care program should include -

Examination of work practices in an effort to reduce skin contact.

- Use of barrier creams on a regular basis.
- Use of proper protective equipment such as chemically resistant gloves. Thin cotton gloves worn under the industrial gloves will help to absorb sweat and make the long term wearing of gloves more practical.
- Education of the workforce in the proper techniques of prevention.
- Use of solvent-free hand cleansing compounds where ordinary soap is not sufficient.
- Use of skin conditioning cream, as required.

METALS

Metals are distinguished from the other elements by the following properties:-

- high reflectivity
- high electrical conductivity
- high thermal conductivity
- mechanical properties of strength and ductility

Chemically they may occur as:

- pure metals, e.g. copper, lead, iron;
- salts, e.g. sodium chloride, copper sulphate
- inorganic compounds, e.g. oxides, acids, phosphine
- organic compounds, e.g. tetraethyl lead, phenyl mercuric acetate

Absorption of Metals

In the workplace, metals and their compounds are absorbed primarily into the body through the lungs. Ingestion and absorption through the skin are less important.

The hazard of a metal is dependent on its chemical form. Any process which generates metal in a form which can be inhaled may pose a hazard to health. Processes which can generate metal dusts and fumes in air are hazardous. Fume consists of visible particles of metal oxide condensed from metal vapour which has reacted with oxygen. Processes which generate metal dust and fume include:

- **Welding** -The extreme temperature involved causes the metal to boil, producing large amounts of fume. The lower temperatures of brazing and soldering processes produce less fumes.
- **Grinding** - Generates dust in air. It is a problem in fettling shops when removing rough edges from cast metal.
- **Cutting** - Thermal (heat) and machine cutting generate fume and dust respectively.
- **Foundry** - The melting of metal and pouring of casts liberates copious fume.
- **Smelting** - The recovery of metal from ore or scrap generates copious fume.
- **Polishing** - High speed metal polishing generates fine airborne dust.

Airborne contamination by metal compounds may also occur in the form of mist and vapour.

- **Metal mist** - This is usually associated with electroplating.
- **Metal vapour** - This is relevant to mercury and may result from spills of mercury and many results from spills of mercury or workplaces where large amounts of metallic mercury are used.

HEALTH HAZARDS OF METALS

Metal Fume Fever

This condition is caused by inhalation of metal fumes (particularly fresh fumes) or dusts of a respirable particle size. The most common cause of metal fume fever is zinc. Fumes of copper, cadmium, magnesium, aluminium, iron, manganese, nickel and tin can also cause metal fume fever.

Metal fume fever is often associated with:-

- brass foundries
- welding operations.

The symptoms and sequence of events are:

Dust and fume inhaled

4 - 12 hours

delay

sweet/metallic taste in mouth
dryness and irritation of throat

cough, shortness of breath,

24 - 48 hours

general malaise, fatigue,
pains in muscles and joints

fever and chills (102 - 104 degrees F)
profuse sweating

fever and other symptoms subside

The symptoms are often mistaken for a common cold or flu. Immediately after the illness, the worker has a tolerance or short-lived immunity to the metal fumes/dust. However, after a weekend or holiday, the illness may recur following further exposure.

Where the cause is zinc or copper, there is no long-term health risk. Zinc and copper are essential elements for bodily functions and the body deals with a temporary excess readily, and without any risk of permanent lung disease, cancer or other serious effect.

Systemic Toxicity

The absorption of some metals or their compounds in small concentrations can result in toxic effects, e.g. lead. This intake is usually due to poor workplace conditions or work practices. Health effects can be acute or chronic.

Skin Effects

Some metals can pose a hazard to the skin, resulting in an allergic reaction on contact. Two such metals are nickel and chromium which can cause serious skin conditions.

Carcinogenic Effects

Some metals are recognised carcinogens. Special precautions need to be taken when handling materials containing such metals. Arsenic is a prime example with the potential to cause skin cancer, and also the possibility of lung cancer. Chromium is also a possible cause of lung cancer. The welding of stainless steel is a common source of exposure to chromium fume. Precautions should be taken to minimise exposure to the dusts and fumes of these metals.

METHODS OF CONTROLLING WORKPLACE HEALTH HAZARDS

Because industry is geared to use hazardous chemicals, it must adopt practices which will allow it to do so without creating undue risks for its workers. These control procedures are fundamental to good occupational hygiene practice in the workplace.

There are a number of ways to control the risks associated with hazardous chemicals. Some control measures are more effective than others. Control measures can be ranked from the highest level of protection and reliability to the lowest. This ranking is known as the *hierarchy of control*.

You must always aim to eliminate a hazard and associated risk first.

Control measure	Comment	Examples of use
Elimination	Control the hazard at the source. This is the most effective control measure and removes the risk by removing the hazard or changing the work processes.	Contract tasks out to specialists who have appropriate facilities; remove welding fumes by ventilation.

If elimination is not reasonably practicable, the risk must be minimised by using one or more of the following approaches:

Control measure	Comment	Examples of use
Substitution	Replace the hazard (e.g. plant or substance) with another that has a lower risk.	Use a machine with better guarding; use a less hazardous chemical that does the same job.
Isolation	Remove or separate people from the source of the hazard.	Use rubber mats to lift workers off a concrete floor; segregating work processes.
Engineering controls	Change the physical characteristics of the plant or workplace to remove or reduce the risk.	Modify a machine so it can be used by remote control.

If risk then remains, it must be minimised by implementing administrative controls, so far as is reasonably practicable.

Control measure	Comment	Examples of use
Administrative measures	Use policies, procedures, signs and training to control risk.	Review systems of work so that nobody works alone at night; train workers in safe lifting techniques.

Any remaining risk must be minimised with suitable personal protective equipment (PPE).

Control measure	Comment	Examples of use
Personal protective equipment (PPE)	Provide equipment or clothing designed to protect the worker.	Provide hats and long shirts to protect outdoor workers against the sun.

Administrative control measures and PPE rely on human behaviour and supervision and when used on their own, tend to be the least effective ways of minimising risks.

Substitution

Some materials, without doubt, would be better off out of the workplace. For example, widespread use of cancer causing chemicals in industry could have disastrous consequences. For this reason, the solvent benzene, which is well known to cause leukaemia has been widely substituted by much less toxic aromatic solvents such as xylene. Most of the industrial processes which formerly used asbestos fibre in Australian industry have been either done away with or the asbestos has been substituted by much less hazardous synthetic mineral fibres or cellulose.

Substitution is a very widely used control procedure; as a WHSO, you should investigate, whenever possible, to find possible substitutes for hazardous chemicals. Even the form of a material can help hazard control. For example, a process using a fine powder which drifts around in the workplace air might be substituted with small pellets without detriment to the process and the problem is reduced markedly. On a more complex scale, one process might be replaced by a less hazardous one to avoid noxious intermediates or by-products (as in the production of certain pesticides to avoid dioxin contamination). However, decisions in such areas often require very high levels of technical expertise.

Engineering out the Hazard by enclosing and/or isolation

Most often, however, the hazardous material is in the workplace to stay. Steps then have to be made to control all exposures to the hazard or “engineer out the hazard”.

The first step is to contain the material at its processing point or wherever it might be generated. This stops it spreading and makes the task of providing good working conditions easier. A typical approach is to build a box or cabinet around the process or the hazard generator.

Enclosures are used to prevent the spread of dusts, organic vapours and gases. Sometimes the process is fully enclosed for the purpose of flooding the entire process with a gas or vapour e.g. in a chemical reaction. The dusts created or gases used in these enclosures often have to be removed at some time during the production, so it becomes necessary to fit it up with Local Exhaust Ventilation to carry away the hazardous material.

Isolation of a procedure is similar to enclosure in its effect. It removes possibility of workers being exposed to hazardous chemicals by making it impossible for workers to come into contact with the hazardous chemical. Isolation procedures are often used for handling radioactive materials or toxic drugs. Glove boxes are often used to isolate workers from the hazardous chemicals they are handling.

Some other less dramatic forms of isolation can be found such as:

- using plastic isolation barriers around asbestos removals
- locating petrol driven engines out of doors
- isolating clean air intakes away from sources of possible contamination.

Ventilation of the Workplace

Good ventilation is often crucial in the control of hazardous chemicals and proper ventilation often is sufficient to control the hazard.

Hazardous chemicals have a habit of becoming fugitive and escaping into the workplace air. Ventilation is all about maintaining the quality of air in the workplace fit to be breathed. As a general rule, always aim to replace contaminated air with fresh air and if in doubt, ventilate.

There are three basic forms of VENTILATION for the workplace.

- Local Exhaust Ventilation
- Natural Ventilation

- General Dilution Ventilation

Local Exhaust Ventilation

Local exhaust ventilation, or extraction ventilation, is necessary where control of hazardous chemicals is essential. This is a point source extraction which specifically prevents the workplace air from becoming contaminated.

Design features include:

- designed for a particular job, e.g. a saw, a grinder
- have a capture velocity calculated for the design to overcome tendency of contaminant to disperse.
- carry contamination completely away from workplace
- are often designed so that worker does not enter the zone of extraction
- are designed to take into account the presence of user.

Several types of these ducted systems are possible, e.g.

- fume cupboards for laboratories
- extraction hoods over hot processes
- re-locatable point source extractors for welding
- push-pull extractors over electroplating baths
- down draught tables for controlling heavy metal dusts
- enclosed and extracted booths for acid vapour catalysis in foundries
- dust extractors on power tools.

Local Exhaust Ventilation is the best kind of contaminant control, although it may initially also be the most expensive. These LEV's are often followed up by a separator device such as a cyclone dust collector, a bag house filter, a wet scrubber, a catalytic converter or an electrostatic precipitator to remove the contaminant.

Natural Ventilation

Natural ventilation is to do with matching building design and the processes employing hazardous chemicals to natural prevailing air movements. Design features of significance

- adequate windows and doors opened
- use the prevailing breezes to carry contaminants
- away from the breathing zone
- use of lantern roofs or high louvered roof section
- conduct hazardous operations outdoors rather than indoors if applicable

Natural ventilation can be applied to situations involving relatively minor hazards.

NATURAL VENTILATION IS DEFINITELY NOT RECOMMENDED FOR VERY HAZARDOUS OPERATIONS.

General Dilution Ventilation

General Dilution Ventilation can be used if the general workplace air body is large and dispersal of the contaminant does not cause undue problems. For example, some solvent vapours may be dispersed. Design features of significance:

- use of fan to direct contamination away from breathing zone of worker.
- usually need good air movement.
- large reservoir of workplace air needed.
- not recommended for hazardous chemicals.
- might be used where expensive systems are not warranted or practicable.

Administrative controls

- working reduced schedules
- preventing certain individuals doing certain tasks
- monitoring health and removing when in danger

All regulations limiting the exposure of persons to certain time weighted concentrations of hazardous chemicals are effectively administrative controls, but there are much higher levels of administrative controls possible.

In some instances, the amount of exposure to a hazardous chemical can be limited by restricting the time of exposure. So instead of working 8 hours, exposure time might be limited to 2 hours or 4 hours per day as in the case of noise exposure.

In the past, lead regulations have acknowledged that exposure of women of child bearing age to lead had a risk of damage to the foetus and consequently, young women were restricted from working in this industry.

Workers who have developed a disease or who are in danger of developing an occupationally related illness might be removed from their job. It might only be temporary removal if the risk to health can be averted if the body can recover (e.g. lead exposure), or it may be permanent if the risk is cumulative and non-reversible (such as a cumulative dust exposure).

In both these cases, a medical or health surveillance program is a strong administrative control.

Personal Protection

In some instances in the workplace which uses hazardous chemicals, it is not always practicable to use substitution or ventilation techniques to control the hazards. The hazards may be to skin i.e. dermal, or to hearing, sight or body in the form of radiation or vibration. In such cases, avenues of personal protection need to be explored.

In other instances, the hazardous situation might arise only very occasionally, and the installation of elaborate control procedures is not economically warranted. Lastly, engineering control measures may not be practicable because of the nature of or location of the task. Because the major contact with the hazardous chemicals in the working environment occurs by way of the organ of the lung, we consider the principles related to respiratory protection.

Respiratory Protection:

Respiratory Protective Equipment (RPE) is divided into 2 broad classes.

- respirators which purify the contaminated air by use of a filtering medium
- devices which provide air or oxygen from an uncontaminated source such as a bottle or compressor.

RPE has to be properly selected to provide the protection against the hazardous chemicals found in the workplace. For example, there are RPE's to provide protection against:

- dust and particulates
- gases and organic vapours
- acid or alkaline vapours
- combinations of the above e.g. dust and organic vapour

In addition, special RPE is available for work in:

- oxygen deficient atmospheres (use compressed air source)

RPE is designed in several efficiencies for use according to the degree of protection required. For particle respirators, there are the following:

- Class P1 - intended for use against mechanically generated particles e.g. silica, asbestos.
- Class P2 - intended for use against both mechanically and thermally generated particles e.g. metal fumes
- Class P3 - intended for use against all particles including highly toxic material e.g. beryllium.

The Australian Standards AS1715 and AS1716 set out the specifications for selection and performance of PPE for use in Australian workplaces.

In selecting respirators for use in the workplace, you will need then to consider:

- what is the nature of the hazard (s) i.e. gas, dust, oxygen deficiency?
- what is the extent of the hazard i.e. heavy dust clouds, occasional exposure, mixed exposures?
- how much protection is needed?
- what is the level of protection provided i.e. the nominal protection factor of the various RPE's

Once you have answered these questions, then you need to address matters of:

- facial fit
- comfort and acceptability for the particular task
- respirator maintenance program

Manufacturers of respiratory protection provide a range of materials which will aid you in selecting the correct style of make and the correct filtration media for the specific hazardous chemicals which may be found in your workplace.

Importance of facial fit - The effectiveness of a tight-fitting respirator facepiece, such as a half-face or full-face respirator that uses straps, relies on getting a good seal with the wearer's face. If a respirator does not fit properly the wearer will not get the expected level of protection.

Use both of the following methods to make sure a respirator is a suitable fit for each worker:

- Fit test
- Fit check.

Facial hair, including beards, moustaches, sideburns and stubble, between the sealing surface of a tight-facing facepiece and the face will stop the respirator from sealing properly.

Workers should be clean shaven where the respirator facepiece comes in contact with the skin before wearing their respirator.

Fit testing detects if air leaks into the respirator through gaps in the seal. Fit testing can be carried out in-house by a competent person, manufacturer or supplier, or service provider.

Fit checking is carried out each time a respirator is put on. A fit check is a quick test to ensure the respirator, which has been fit tested, has been properly positioned on the face and a good seal has been achieved.

Remember, personal respiratory protection is the least favourable of all the control methods because of the encumbrance it puts upon the worker. In some cases, it is the most effective, the most suitable and the most economic because of the impossibility of using other control procedures. In a few cases, it is also absolutely essential because of the dangerous nature of the hazards being handled e.g. isocyanate spray painting, or oxygen deficient atmospheres or asbestos stripping. But in most ordinary factories and workplace situations, it is better to try to control the hazards at their source rather than let the hazardous material go free and then try to protect the worker.

MONITORING THE LEVEL OF HAZADOUS CHEMICALS IN THE AIR

Monitoring of the Workplace

When finding that a workplace has an airborne hazardous chemical, the next questions to ask are:

- What is the nature of the contaminant?
- How much of the contaminant is present in the air?

Strong emphasis is given to monitoring because it is the basis of decision making.

To monitor successfully, in order that proper control decisions can be made, the following steps need to be taken.

- Find out the nature of the airborne contaminants. Are they gases, organic or chemical vapours, are they dusts such as asbestos or quartz?
- Secondly, decide on the appropriate type of monitoring. Some monitoring can be undertaken directly by the Health and Safety Officers, but most monitoring tasks will need services of hygienists, inspectors etc., who have the proper instrumentation and laboratory backup.

Monitoring tends to fall into two classes:

- Personal monitoring
- Area monitoring

Both are used extensively by occupational hygienists.

PERSONAL MONITORING

Personal monitoring involves breathing zone sampling. Much of the occupational hygiene monitoring involves personal monitoring, because personal sampling best reflects the exposure of the person while they are in the workplace exposed to a hazardous chemical or material. This is the only type of monitoring is the only monitoring that can be used to determine if an exposure standard is being met.

For workers exposed to airborne hazardous chemicals, we need to know just how much that worker is exposed to. Only then can you:

- calculate their personal time weighted average exposure
- address the problem of proper control or respiratory protection
- help identify any idiosyncrasies in worker behaviour which help or worsen their exposure e.g. does the worker adopt work habits which put them at risk

For practical purposes, personal sampling usually involves attaching some kind of monitoring device to a shirt lapel, collar or pocket.

AREA MONITORING

A second type of sampling is Area Monitoring. It has to be used if the sampling device cannot be worn or is not transportable and the sampler is located in a fixed point e.g. a cotton dust sampler.

Other reasons for employing a STATIC SAMPLING

- to check the emission of dust / vapour from a process
- to check on the performance of control measures

As a guide, personal sampling for personal exposure is always superior to area monitoring. Sometimes the exposure figure is 4 times higher in the personal breathing zone than is indicated by area sampling. This is because the worker is often the one creating the hazard or they move into areas of higher potential risk much more than is indicated by a general background sample.

Some Examples of Monitoring in the Workplace

Workplace monitoring is regularly undertaken for a range of different airborne hazardous chemicals. The purpose of such monitoring is to evaluate the exposures of workers to the airborne hazardous chemicals and adjust control procedures accordingly. Some of these tests are relatively simple and can be undertaken directly by a WHOS. A number of direct reading instruments (oxygen, carbon monoxide) are available which can be used effectively by the WHSO. More complex testing will require the services of a competent occupational hygienist, backed up by quite extensive laboratory services.

Some different kinds of monitoring are:

- monitoring for dusts such as asbestos, respirable crystalline silica dusts, wood or grain dusts.
- monitoring for metal dusts, metal salts or metal fumes such as lead, copper, zinc oxide or mercury vapour.
- monitoring for gases such as carbon monoxide or acid gases such as hydrogen sulphide, formaldehyde, sulphur dioxide. Monitoring might include monitoring for lack of oxygen or excess carbon dioxide.
- monitoring for organic vapour contaminants and solvents such as paint solvents, pesticides, isocyanates, sterilant gases.

HEALTH MONITORING

Health monitoring of a person means monitoring the person to identify changes in the person's health status because of exposure to certain substances. It involves the collection of data in order to evaluate the effects of exposure and to confirm that the absorbed dose is within safe levels. This allows decisions to be made about implementing ways to eliminate or minimise the worker's risk of exposure, for example, reassigning to other duties that involve less exposure or improving control measures. Health monitoring is carried out by or under the supervision a register medical practitioner.

Health monitoring may include:

- consultation with a registered medical practitioner
- a physical examination, for example skin checks or lung function (spirometry) test
- clinical tests, for example urine or blood test
- X-rays.

Hazardous chemicals for which health monitoring may be required includes:

- asbestos
- a chemical listed in schedule 14 of the Work Health and Safety Regulation, including lead (inorganic)
- any other hazardous chemical for which there is a valid test method for detecting health effects or exposure.

Health monitoring is not an alternative to implementing control measures. If the results indicate that a worker is experiencing adverse health effects or signs of exposure to a hazardous chemical, the control measures in place must be reviewed and if necessary revised.

Biological monitoring

Biological tests on the worker can provide information on the health status of the worker, whereas air monitoring cannot. For example, blood cyanide tests on workers in the cyanide manufacturing industry can indicate whether workers need to be removed from further cyanide exposure. Biological monitoring is also useful where skin absorption, rather than inhalation, is the primary route of entry.

Schedule 14 of the Work Health and Safety Regulation states what biological testing is required, if any, for the substances listed and these must be carried out in accordance with the Regulation. The Regulation does not list all the available biological tests that are available for hazardous chemicals, therefore the register medical practitioner needs to have information about the hazards at the workplace to know what tests may be required.

Below is a list of some regular biomonitoring tests for gases and vapours or aerosols:

- MOCA (methylene chloroaniline) in workers making polyurethane elastomers
- hippuric acid resulting from exposure to toluene
- mandelic acid following exposure to styrene vapour in fibre glassing
- fluoride following gaseous fluoride exposure in aluminium smelting
- phenols amongst timber preservation workers blood
- organo-phosphate pesticides (chloinesterase activity e.g. for crop sprayers)
- organochlorine pesticides (eg. pest control operators in termite eradication)
- cyanide (e.g. in cyanide plant workers, or gold cyanidation plant operators)
- carbon monoxide (accidental exposure) e.g. petrol vehicle exhaust

SOURCES OF INFORMATION

It is important for the WHSO to realise that the field of occupational health and hygiene is a large and complex one.

The information given in these notes has covered only a few aspects of occupational health and hygiene. The WHSO will be required to pursue matters specific to his/her own workplace often at a more detailed level.

Knowing how much and where to acquire the relevant information about a subject is a skill. In the majority of cases, basic information will suffice (leaflets, SDS, information sheets etc). In other situations, greater detail may be required (reference books, Occupational Health and Safety Encyclopaedias etc). On some occasions, extensive research or assistance from professional occupational health and safety organisations may be necessary.

- Find an occupational hygienist
- Safe Work Australia
- Managing the Risks of Hazardous Chemicals in the Workplace Code of Practice 2013
- Information about health monitoring

Version	Date	Author
1	30/06/2018	WHSQ