NEBOSH International General Certificate in Occupational Health and safety

Element 7

Health hazards - chemical and biological agents

Element 7: Table of Contents

7.0 Learning outcomes

The learner should be able to:

- Do a general risk assessment in their own workplace – profiling and prioritising risks, inspecting the workplace, recognising a range of common hazards, evaluating risks (taking account of current controls), recommending further control measures, planning actions.

  5-11 **Produce** a risk assessment of a workplace which considers a wide range of identified hazards (drawn from elements 5-11) and meets best practice standards (*'suitable and sufficient'*).

7.1 Forms of, classification of, and health risks from hazardous substances

Definition of hazardous substance

A *'substance hazardous to health'* is one:

a. which is listed as dangerous for supply and has an indication of danger specified for the substance as very toxic, toxic, harmful, corrosive or irritant

b. for which the Health and Safety Executive has approved a workplace exposure limit (WEL)

c. which is a biological agent

d. which is dust (other than those covered in **a.** or **b.** above) present at a concentration in air equal to or greater than:

- 10 mg/m^3, as a time-weighted average over an 8-hour period, of inhalable dust
- (4 mg/m^3, as a time-weighted average over an 8-hour period, of respirable dust

e. which because of its chemical or toxicological properties, and the way it is used or is present at the workplace creates a risk to health.

Forms of chemical agent

Most substance can exist in all three states of matter, *i.e.* as a solid, a liquid, or a gas. Whether a substance is solid, liquid or gas depends on its temperature and the pressure placed on it.

At room temperature (21^{o}C) and atmospheric pressure water is a liquid, if the temperature is lowered to 0^{o}C it begins to freeze and at – 10^{o}C is solid ice. If the temperature increases to 100^{o}C the water boils and becomes steam. Chemically it is still water but it is in its gaseous state.

Whether a substance is in its solid, liquid, or gaseous state has a major bearing on the way it may enter the human body and cause harm: gases are likely to be breathed in, liquids may contaminate clothing and be absorbed through the skin, and handling solids may result in contaminated food being eaten.

A vapour is the gas phase of a material, which is normally liquid under standard conditions. Many liquid chemicals evaporate at room temperature, which actually means that they form a vapour and stay in the air.

Very fine particles of solid (or liquid) suspended in air, behave similarly to gases and can be breathed in. Particles suspended in air are termed aerosols, the particle size will determine how far into the respiratory tract the particle travels (Table 7.1).

Particle	Size (Ø)	Description
Dust	1-75 µm	Solid inanimate particle created by attrition – grinding, crushing, sanding, milling etc. Particles larger than 75 µm are unlikely to remain airborne and are termed grit. The particles that enter the nose and mouth during breathing (and can therefore be deposited within the respiratory tract) are termed *total inhalable dust* – TID). Particles able to enter the gaseous exchange areas of the lung (alveoli) are termed *respirable dust* and are usually 0.5 µm to 7 µm. Smaller particles are breathed out.
Fibres		Not notionally spherical. Have aspect ratio of at least 1:3 (*i.e.* 3x longer than wide). Natural mineral – asbestos Natural vegetable – cotton/jute Synthetic mineral – MMMF (man-made mineral fibres)
Fume	<1 µm	Formed by the vaporisation or oxidation of molten metal *e.g.* lead fume/welding fume.
Mists	>20 µm	Liquid droplets – created by spraying, pickling, foaming and electroplating.
Smoke	<1 µm	Combustion products – particles suspended in gases.
Ø= nominal/aerodynamic diameter µm = micrometre (micron) (1/1000th of a millimetre) > < = greater than/less than		

Table 7.1: Airborne particles (aerosols)

Forms of biological agent

The main classes of harmful biological agent (micro-organisms) are:

- bacteria
- viruses
- fungi.

Bacteria

Bacteria are microscopic organisms (typically < 1 μm) which lack cells with internal membranes. Bacteria contain DNA, but differs from cellular DNA in that it has a circular arrangement, rather than linear.

Bacteria are classified according to their basic shapes:

- cocci – spherical, *e.g.* staphylococcus aureus (MRSA is methicillin (antibiotic) resistant staphylococcus aureus)
- spirochaetes – corkscrew shaped *e.g.* leptospira (Weils disease)
- bacilli – rod shaped.

Viruses

Virus are infectious agents consisting of genetic material (DNA or RNA) surrounded by a protective coating of protein, called a capsid, with or without an outer lipid envelope.

Viruses are 20 to 100 times smaller than bacteria and cannot be seen by light microscopy. The largest viruses (poxviruses) are about 450 nanometres (nm) in length and the smallest viruses (polioviruses) are about 30 nm.

Viruses are not really *'alive'* as they cannot reproduce outside of a living cell. They reproduce by transmitting their genetic information from one cell to another.

Viruses can damage or kill the cells that they infect, causing disease in infected organisms. Some cause cancers by stimulating cells to grow uncontrollably.

Viruses cause many infectious diseases that have no cures. Antiviral treatments are difficult to create because of the large number of variant viruses that can cause the same disease. A further concern is the difficulty in disabling a virus without disabling healthy cells.

Blood borne viruses (BBV) including human immunodeficiency virus (HIV) and Hepatitis C are significant occupational health hazards.

Fungi

Fungi are a diverse group of organisms that obtain food by direct absorption of nutrients. The food is dissolved by enzymes that the fungi excrete, is then absorbed through thin cell walls, and is distributed by simple circulation, or streaming, of the protoplasm.

Fungi may be single-celled or multi-cellular. Fungal infections include ringworm and athletes foot. In healthy people fungal infections are usually mild, involving superficial sites, and clear up spontaneously.

Occupationally the spores of the aspergillus fungus can cause aspergillosis, an extrinsic allergic alveolitis, commonly called *'farmers lung'*.

Classification of substances hazardous to health

Introduction – GHS and CLP

The United Nation's (UN) Globally Harmonised System of Classification and Labelling of Chemicals (GHS) aims to improve worker safety throughout the world by introducing a com¬mon set of hazard criteria and labelling elements to be used for chemicals. The GHS aims to ensure that chemical suppliers identify the hazards of their products, package them safely and com¬municate information about the hazards through labels and other documents.

The EU Regulation on the Classification, Labelling and Packaging of Substances and Mixtures (CLP) adopts GHS within the EU.

Primary classifications

The primary classification system for substances hazardous to health is as follows:

- **Irritant** Chemicals that may cause inflammation to the skin or other mucous membranes.
- **Corrosive** Chemicals that may destroy living tissue on contact.
- **Harmful** Chemicals that may cause damage to health.
- **Toxic** Chemicals that at low levels cause damage to health.
- **Very toxic** Chemicals that at very low levels cause damage to health.

- **Carcinogenic** Chemicals that may cause cancer or increase its incidence.
- **Mutagenic** Chemicals that induce heritable genetic defects or increase their incidence.
- **Reproductive toxin** Chemicals that produce or increase the incidence of non-heritable effects in progeny and/or impairment in reproductive functions or capacity.

Labelling

CLP information to be provided on labels:

- red-framed pictograms
- a signal word *'Danger'* for severe hazards and *'Warning'* for less severe hazards
- hazard statements
- precautionary statements provide information about the type of hazard within a hazard class
- give advice on preventive and emergency response requirements.

Hazard (H) statements

Hazard statements replace the previously provide information about the type of hazard involved. Some H statements may be used for more than one hazard category within a hazard class, and therefore the H statements alone do not describe the classification – the hazard class and category also need to be mentioned.

Example H statements include:

- **H240** – Heating may cause an explosion.
- **H320** – Causes eye irritation.
- **H401** – Toxic to aquatic life.

Figure 7.1: CLP Pictograms

(The health hazard pictograms are explained later in Table 7.2)

Precautionary (P) statements

Precautionary statements give advice on preventive measures to take, emergency response actions such as first aid and advice on safe storage and disposal.

Normally there will be a maximum of six P statements on the label, unless the chemical is particularly hazardous. Other relevant P state¬ments may be included in the safety data sheet for the chemical.

Example P statements include:

- **P102** – Keep out of reach of children
- **P271** – Use only outdoors or in well-ventilated area
- **P410** – Protect from sunlight.

Table 7.2 which follows shows the relationships between CLP pictograms, signal words, hazard class and category and hazard statements.

CLP pictogram and signal word	Hazard class and category	Hazard statement
Acute toxicity		
	Danger	Acute toxicity Category 1 Acute toxicity Category 2	**H300**: Fatal if swallowed **H310**: Fatal in contact with skin **H330**: Fatal if inhaled
		Acute toxicity Category 3	**H301**: Toxic if swallowed **H311**: Toxic in contact with skin **H331**: Toxic if inhaled
	Warning	Acute toxicity Category 4	**H302**: Harmful if swallowed **H312**: Harmful in contact with skin **H332**: Harmful if inhaled

Table 7.2: CLP pictograms, signal words, hazard class and category and hazard statements (1 of 4)

CLP pictogram and signal word	Hazard class and category	Hazard statement
Skin corrosion and irritation		
	Danger	Skin corrosion Category 1A	**H314:** Causes severe skin burns and eye damage
		Skin corrosion Categories 1B & 1C	
	Warning	Skin irritation Category 2	**H315:** Causes skin irritation
Eye damage and irritation		
	Danger	Eye damage Category 1	**H318:** Causes serious eye damage
	Warning	Eye irritation Category 2	**H319:** Causes serious eye irritation
Sensitisers		
	Danger	Respiratory sensitiser Category 1 and Subcategory 1(A) and 1(B)	**H334:** May cause allergy or asthma symptoms or breathing difficulties if inhaled
	Warning	Skin sensitiser Category 1 and Subcategory 1(A) and 1(B)	**H317:** May cause an allergic skin reaction

Table 7.2: CLP pictograms, signal words, hazard class and category and hazard statements (2 of 4)

CLP pictogram and signal word	Hazard class and category	Hazard statement
Germ cell mutagenicity		
 Danger	Germ cell mutagenicity Category 1A	**H340:** May cause genetic defects (route of exposure, if applicable)
	Germ cell mutagenicity Category 1B	
 Warning	Germ cell mutagenicity Category 2	**H341:** Suspected of causing genetic defects (route of exposure, if applicable)
Carcinogenicity		
 Danger	Carcinogenicity Category 1A	**H350:** May cause cancer (route of exposure, if applicable)
	Carcinogenicity Category 1B	
 Warning	Carcinogenicity Category 2	**H351:** Suspected of causing cancer (route of exposure, if applicable)
Reproductive toxicity		
 Danger	Reproductive toxicity Category 1A	**H360:** May damage fertility or the unborn child
	Reproductive toxicity Category 1B	
 Warning	Reproductive toxicity Category 2	**H361:** Suspected of damaging fertility or the unborn child
	Lactation effects	**H362:** May cause harm to breastfed children

Table 7.2: CLP pictograms, signal words, hazard class and category and hazard statements (3 of 4)

CLP pictogram and signal word	Hazard class and category	Hazard statement
Specific target organ toxicity (STOT) single exposure (SE)		
 Danger	STOT SE Category 1	**H370:** Causes damage to organs (or affected organs) (route of exposure, if applicable)
 Warning	STOT SE Category 2	**H371:** May cause damage to organs (or affected organs) (route of exposure, if applicable)
 Warning	STOT SE Category 3	**H335:** May cause respiratory irritation **H336:** May cause drowsiness or dizziness
Specific target organ toxicity – repeated exposure (RE)		
 Danger	STOT RE Category 1	**H372:** Causes damage to organs (or affected organs) through prolonged or repeated exposure (route of exposure if applicable)
 Warning	STOT RE Category 2	**H373:** May cause damage to organs (or affected organs) through prolonged or repeated exposure (route of exposure if applicable)
Aspiration toxicity		
 Danger	Aspiration toxicity Category 1	**H304:** May be fatal if swallowed and enters airways

Table 7.2: CLP pictograms, signal words, hazard class and category and hazard statements (4 of 4)

Information

Customers have to be informed about the hazards and how to use the chemicals safely. This is done by provision of a *label* and a *safety data sheet*.

Specific guidance documents are available to assist those involved in both the creation of labels and safety data sheets and also the management of hazardous substances in the workplace.

Three of the most important guidance documents are the:

- EU list of Indicative Limit Values
- UK HSE Guidance Note EH40
- US ACGIH list of Threshold Limit values.

EU Indicative Limit Values or, to give them their full name, Indicative Occupational Exposure Limit Values (IOELVs) are health-based limits set under the Chemical Agents Directive (98/24/EC).

The Scientific Committee on Occupational Exposure Limits (SCOEL) advises the European Commission on limits. This committee evaluates the scientific information available on hazardous substances and makes recommendations for the establishment of an IOELV. IOELVs are listed in Directives which require Member States to establish national occupational exposure limits for the chemical agents in question, taking into account the European values. In most cases, this will mean that the British limit will be identical, or very close to the IOELV.

As highlighted in **Section 7.3**, the British limits are called Workplace Exposure Limits (WELs). WELs are concentrations of hazardous substances in the air, averaged over a specified period of time, referred to as a time-weighted average (TWA). Two time periods are used:

- long-term (8 hours)
- short-term (15 minutes).

EH40 contains details of all current WELs together with additional advice and guidance designed to support the implementation of the Control of Substances Hazardous to Health Regulations 2002 (as amended) (CoSHH).

The current edition of EH40 was published in 2018. In the absence of a WEL or where additional, more recent guidance is required reference may also be made to limit values used in other parts of the world, notably the USA.

The American Conference of Governmental Industrial Hygienists (ACGIH) publishes an annual list of threshold limit values (TLVs). The TLV of a chemical substance defined as the level to which it is believed a worker can be exposed day after day for a working lifetime without adverse health effects.

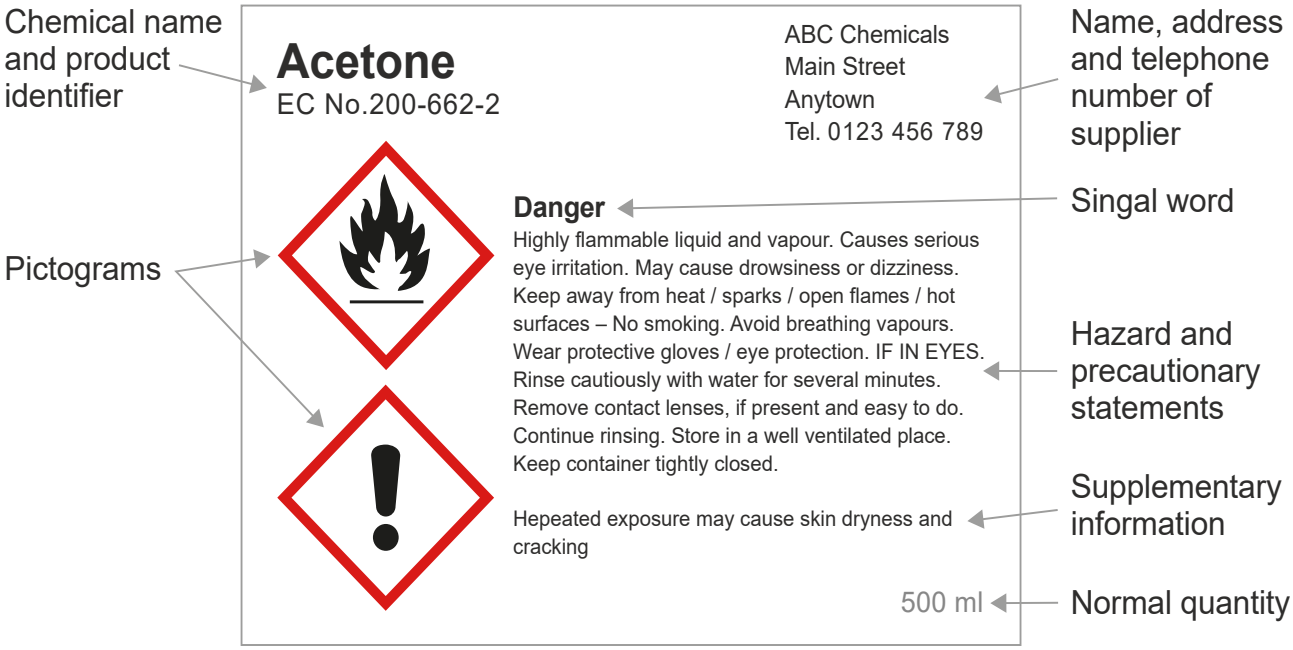


Figure 7.2: Hazardous substance label

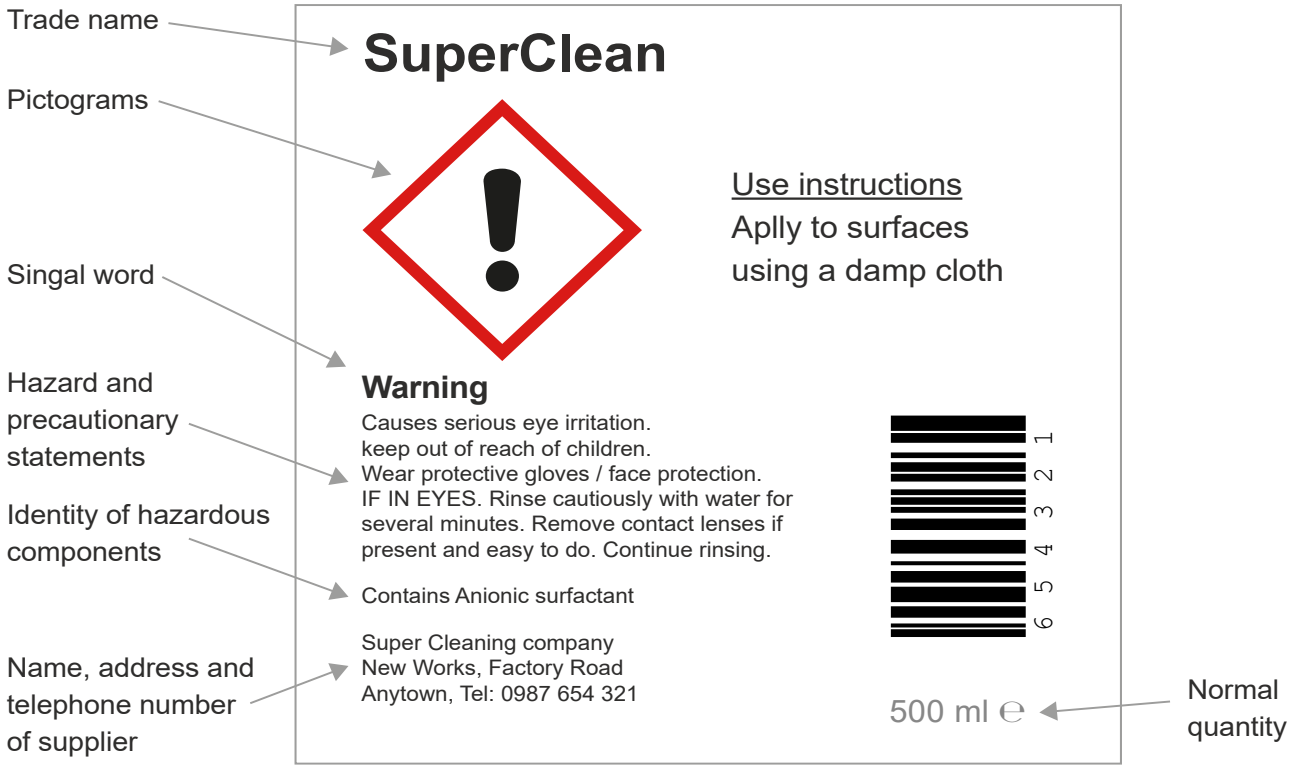


Figure 7.3: Hazardous mixture label

Safety data sheets

The requirements for safety data sheets (SDS) are now laid down in the EU's REACH Regulation.

The safety data sheet contains the technical information necessary to make a risk assessment as required by the Control of Substances Hazardous to Health Regulations (CoSHH).

A SDS should be provided to the recipient free-of-charge, on paper or electronically, either before or at the time of first delivery of the substance or mixture.

The safety data sheet should be dated and contain the following headings:

1. Identification of the substance/mixture and of the company/undertaking
2. Hazards identification
3. Composition/information on ingredients
4. First-aid measures
5. Fire-fighting measures
6. Accidental release measures
7. Handling and storage
8. Exposure controls/personal protection
9. Physical and chemical properties
10. Stability and reactivity
11. Toxicological information
12. Ecological information
13. Disposal considerations
14. Transport information
15. Regulatory information
16. Other information

Packaging requirements

In general the requirements for packaging used for hazardous chemical products are that it should:

- prevent escape of the chemical
- not be adversely affected by the chemical
- be strong enough to withstand normal handling.

Additional considerations include:

- ensuring that packages with replaceable closures continue to prevent escape even after repeated use
- ensuring that some chemicals that are sold to the general public are in packages that are:
    - designed to ensure that they do not attract the active curiosity of children or mislead consumers

- fitted with *'child resistant'* closures/fastenings
- provided with *'tactile warnings'* (raised-profile warnings that can be understood by those with impaired vision).

Acute and chronic health effects

Chemicals can have an adverse health effect as a result of:

- sudden or short term high exposures (acute toxicity)
- repeated low exposures over time (chronic toxicity).

Most chemicals can cause both acute and chronic toxicity depending on the conditions of exposure. Drinking a few too many units of alcohol on an evening out can result in mood changes, nausea, vomiting and hangovers, whereas excessive drinking of alcohol over time can lead to: coronary heart disease, strokes, high blood pressure, liver damage, cirrhosis of the liver, cancers of the mouth and throat and psychological problems such as depression.

Acute toxicity

A single exposure to relatively large amounts of a toxic chemical can overwhelm the body. Examples of acute toxic effects include:

- inhalation of high concentrations of acid vapours burning the respiratory tract
- inhalation or skin absorption of organic solvents causing dizziness and nausea
- inhalation of dusts irritating of the respiratory tract causing dryness in the throat and coughing.

Acute toxic health effects are usually seen within minutes or hours of exposure, however effects may be delayed *e.g.* the symptoms of acute pesticide poisoning may not appear for several days.

The health effects are often temporary, such as skin irritation, sickness or nausea but they can be permanent, *e.g.* blindness, scar tissue, and even death.

Chronic toxicity

Repeated exposures over a period of time can result in the accumulation of a toxic dose of a chemical. Examples of chronic toxicity effects include:

- inhalation of acid vapours eroding tooth enamel leading to extensive tooth decay
- inhalation and skin absorption of some organic solvents damaging nerve tissue
- repeated exposure to quartz dusts causes permanent scar tissue in the lungs.

Generally chronic toxicity appears many years after exposure first began and the effects are often irreversible.

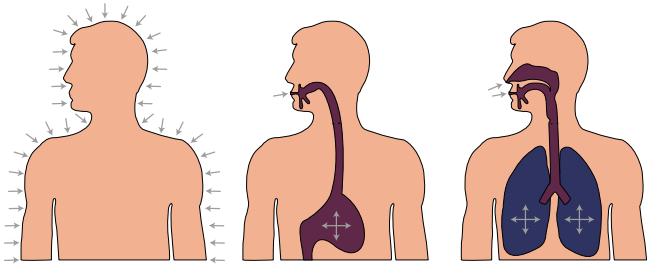
Chronic toxicity occurs in one of two main ways:

- either concentrations bio-accumulate in tissue to a dose level that triggers a response (*e.g.* mercury in the brain, or lead or pesticides in fatty tissue)
- the chemical is broken down in the liver and the breakdown products have a gradual effect until the symptoms are evident (*e.g.* the breakdown products of hexane are neuro-toxic, killing nerve cells in the fingers and toes, eventually sufficient damage is down and the symptoms – numbness, tingling, weakness and pain – are experienced).

Routes of entry

Hazardous substances enter the body in one of four main ways:

- inhalation (breathing in)
- absorption (skin contact)
- injection (skin puncture)
- ingestion (swallowing).



Inhalation (breathing in)

This is the most important route of entry in the occupational context accounting for approximately 90% of illnesses associated with toxic substances.

Effects may be local (in the respiratory tract) or systemic (travel in the blood stream and affect other organs).

Local effects include:

- irritation of the respiratory tract (bronchitis)
- sensitising effect on the lungs (asthma)
- lung tissue scarring
- lung cancers.

Systemic effects depend on the hazardous substance. Different toxic materials affect different target organs *e.g.* inhaled lead compounds can affect the brain.

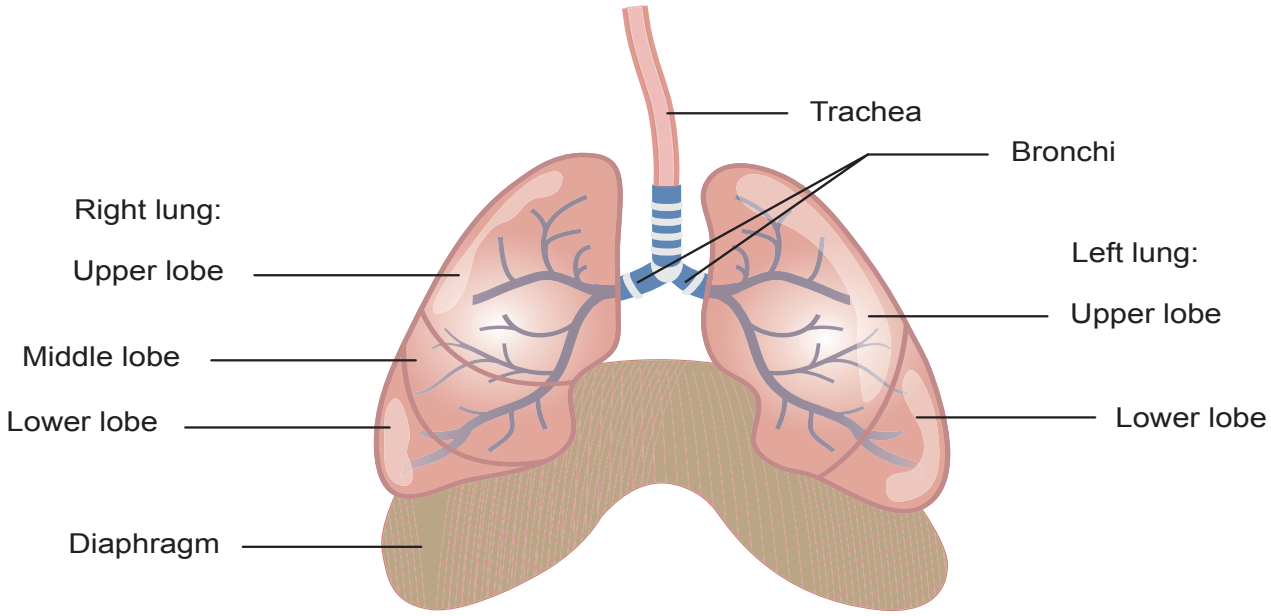


Figure 7.4: Respiratory tract (inhalation route)

Absorption (skin contact)

Some organic substances such as solvents and some micro-organisms can pass through intact skin and mucous membranes into underlying tissues and the blood stream. For organic compounds this is likely to make a significant contribution to the total exposure.

Local effects include:

- burning of the skin/eye
- irritation of the skin (dermatitis)
- sensitising effects (contact dermatitis)
- skin cancer.

Systemic effects will depend on the toxic substance *e.g.* skin absorbed mercury compounds might affect the brain, central nervous system and kidneys.

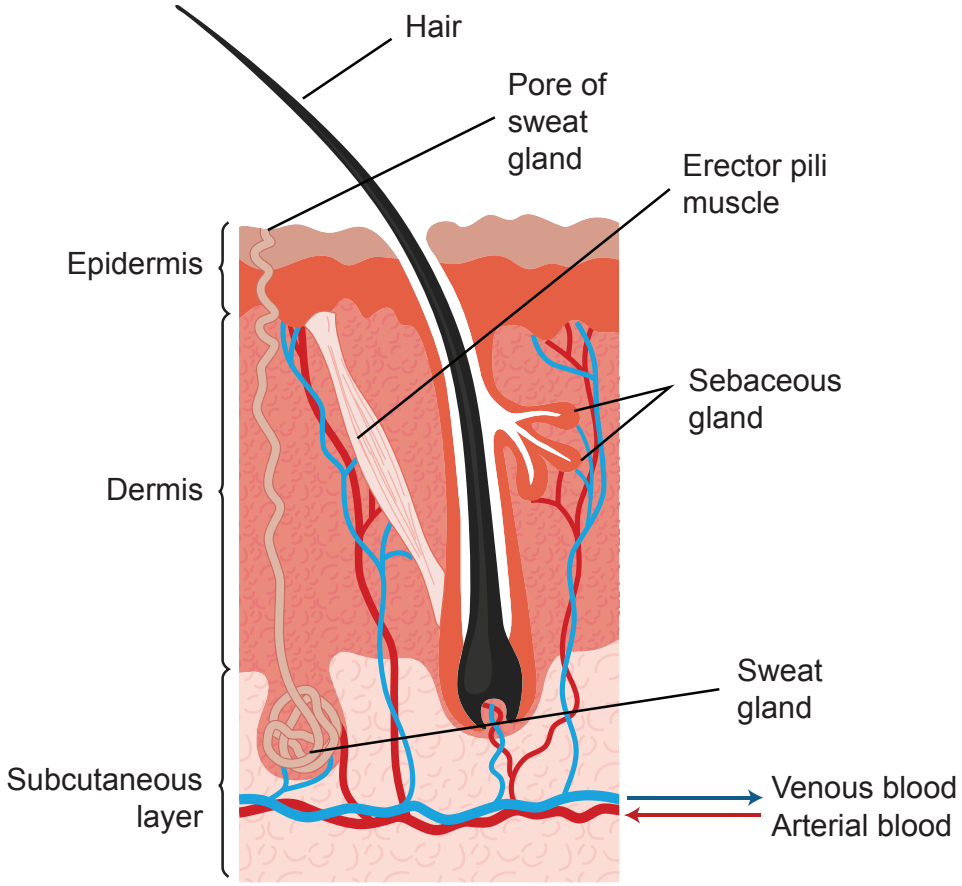


Figure 7.5: The skin (absorption route)

Injection (skin puncture)

Needle-stick injuries provide the route of entry for blood borne viruses.

Ingestion (swallowing)

Ingestion of toxic materials is the least common route of entry. However, it can occur as a result of:

- eating in a contaminated work area
- handling food with dirty hands
- swallowing coughed up inhaled contaminants.

Body defences

The human body is well designed to protect itself from many hazardous substances but not all. The main defence mechanisms of the respiratory tract, skin and digestive system are summarised in Table 7.3.

System	Defence mechanisms
Respiratory tract	• sense of smell • nasal hairs and mucous act filter out larger particles • the change of direction at the top of the nose causes larger particles to fall out of the air stream • coughing and sneezing or swallowing gets rid of these particles • the airways from the trachea through the bronchi and bronchioles get progressively narrower restricting the passage of larger particles • muco-ciliary escalator transports particles up the trachea to the top of the throat to be coughed up and swallowed or spat out • white blood cells in the blood in the capillaries around the alveoli defend against bacteria and other foreign bodies • liver detoxifies the blood.
Skin	• sense of touch • epidermis consists of densely packed flat cell with a thicker layer in the areas more likely to be damaged (*e.g.* palm of hands) • secretions of sebum and sweat protect the skin from excessive water, heat, friction and infection.
Digestive system	• sense of smell and taste • vomiting reflex • acid in the stomach provides a hostile environment for micro-organisms • diarrhoea • liver detoxifies the blood.

Table 7.3: Body defence mechanisms

7.2 Assessment of health risks

The employer is required to make a suitable and sufficient assessment of the risks to his employees' health arising from workplace exposure to substances hazardous to health.

The purpose of the assessment is to enable the employer to make a valid decision about the measures necessary to prevent or adequately control the exposure of their employees to substances hazardous to health arising from the work.

Risk assessment

To be suitable and sufficient the assessment will need to be systematic and comprehensive. The 5 steps approach, outlined in **Element 3** is appropriate:

1. identify the hazards
2. decide who might be harmed and how
3. evaluate the risks and decide on precautions
4. record the findings and implement them
5. review the risk assessment and update if necessary.

Identify the hazards

The assessment should cover all hazardous substances, including those:

- brought into the workplace and handled, stored and used for processing
- produced or given off, *e.g.* as fumes, vapour dust etc. by a process or an activity or as a result of an accident or incident
- used for, or arise from maintenance, cleaning, and repair work
- produced at the end of any process, *e.g.* wastes, residues, scrap etc.
- produced from activities carried out by another employer's employees in the vicinity.

For each hazardous substance, the following information should be gathered:

- the form of the substance (*e.g.* – solid, liquid, gas etc.)
- nature of the substance (*e.g.* raw material, by-product, waste)
- the hazard(s) presented (*e.g.* irritant, corrosive, toxic etc.)

- quantity to be used or created
- concentration of hazardous substance
- OEL, if assigned
- nature of work *e.g.* painting or spraying
- duration and frequency of the work
- routes of entry into the human body.

Information may be obtained from supplier's labels and safety data sheets, from HSE or industry guidance, and from records of incidents, monitoring and health surveillance.

Decide who might be harmed and how

The assessment should consider the ways in which and the extent to which any groups of people could be exposed taking into account the type of work and process, and any reasonably foreseeable deterioration in, or failure of, any control measure provided. Groups to be considered include:

- maintenance workers who may work in circumstances where exposure is foreseeably higher than normal
- office staff
- night cleaners
- security guards
- members of the public such as visitors, patients etc.

Groups of employees who may be at an increased risk should also be considered, for example:

- young people aged under 18 (*e.g.* inexperienced trainees)
- pregnant workers
- disabled workers
- any employees known to be susceptible to certain illnesses such as dermatitis, asthma or other diseases which may be caused by exposure to hazardous substances.

Workers may also be unaware of exposure to a hazardous substance as it may be odourless, the label may be obscured or missing or they may have little knowledge or experience of the substance.

Evaluate the risks and decide on precautions

Employee exposure should be estimated taking into account any information that may be available about:

- the concentration likely to be produced by the work concerned
- the effort needed to do the work and how this may affect the rate and volume of air employees breathed (breathing rate for energetic work can be 3-4x greater than the resting rate)
- the effect of any existing preventive or control measures.

Where operations are complex or specialised and the substances involved have a OEL atmospheric sampling and measurement may be necessary to effectively determine exposure.

The estimate of exposure should then be compared with any existing, valid standards which represent adequate control, *e.g.* a OEL.

If a comparison shows that control is likely to be inadequate then the assessment should detail the measures needed to obtain and maintain adequate control.

Control measures should be applied in accordance with the principles of good practice (see notes on control measures – later).

Record the findings and implement them

A record of the significant findings should present an effective statement of hazards and risks, and the actions taken to protect the health of employees and anyone else who may be affected by the work.

The record provides evidence that all the factors relevant to the work have been systematically considered, and that measures have been implemented to prevent exposure or to achieve and maintain adequate control of exposure.

Review the risk assessment and update if necessary

The assessment is reviewed regularly with the frequency of review determined by the type of risk, the work and the likelihood of changes occurring.

The assessment should be reviewed immediately if there is evidence indicating it may no longer be valid, or a significant change in the circumstances of work.

Evidence regarding the validity of the assessment may arise from:

- the results of examinations and tests of LEV
- the results of monitoring exposure
- the results of health surveillance
- new information on health risks
- reports or complaints about defects in the control systems.

Significant change in the circumstances of work could include:

- a change in the substances used
- plant modification
- a change in process or method of work
- an increase in the volume or rate of production
- workforce reductions resulting in additional pressures on remaining employees.

Hazardous substance monitoring

Monitoring of hazardous substances is necessary:

- when failure of control measures could result in a serious health effect
- to demonstrate that an OEL is not being exceeded
- as an additional check on the effectiveness of control measures
- when changes in work occur that could affect employees' exposure (*e.g.* increase in quantity of a substance used, new systems of work or new plant).

Monitoring is not necessary if it is immediately obvious that exposure is being adequately controlled, and monitoring is not appropriate unless a reliable, effective monitoring technique is available.

Simple observational techniques

Dust particles are often too small to be seen by the naked eye. Using a dust lamp (Tyndall lamp) to pass a strong beam of light through a dust cloud makes the dust particles visible to the observer by forward light scattering.

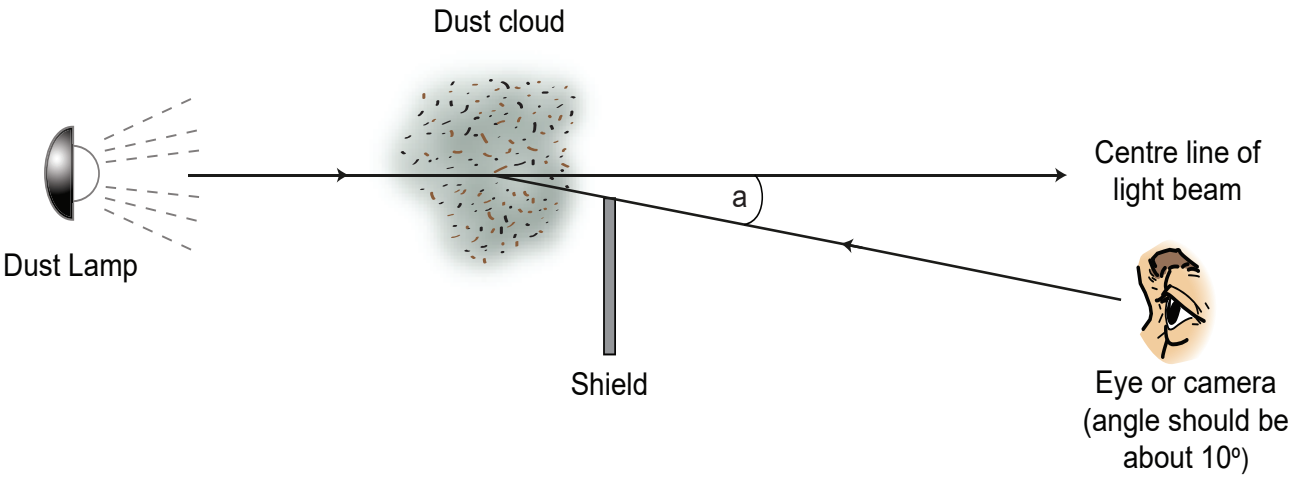


Figure 7.6: Tyndall light beam

Sampling of airborne contaminants

There are several key choices to be made in determining the appropriate approach to sampling airborne contaminants.

The first choice is between *short term (grab) sampling* techniques or *long term sampling* techniques. This is like comparing a photograph to a film. A grab sample takes an immediate sample of air for identification of the contaminant and a *'snap shot'* of its concentration in air at that time.

Long term sampling techniques sample air over a reference period of time (it does not necessarily have to be a long time), using a calibrated air pump to deliver a known volume of air to the sampling device. This allows calculations to be made of time weighted average exposures which can be compared to Occupational Exposure Limits (OEL) (see **SECTION 7.3**).

Long term sampling techniques may use *personal samplers* or *static (environmental) samplers*. Personal samplers are designed to measure the specific exposure of an individual by taking air from the workers *'breathing zone'*. Static sampling equipment is positioned in the workplace and provides a measure of general workplace airborne contamination over time.

Sampling equipment may be *direct reading* or *indirect reading*. Direct reading equipment gives an immediate, in-situ reading, and includes stain detector tubes and more sophisticated equipment such infra-red analysers (spectrophotometers). Indirect reading equipment requires a sample to be taken to a laboratory for analysis.

Air may be sampled passively or actively. *Passive air sampling* techniques allow air to diffuse over the sampling head which may be a badge, impinger/bubbler or dosimeter tube. *Active sampling* uses a calibrated air pump to draw a known volume of air over the reagent over a known period of time.

Examples

Hand bellows and stain detector tubes

Hand bellows and stain detector tubes are typically referred to by the trade name *'Draeger'* (There are other manufacturers such as Kitigawa). A hand bellows is used to draw a known volume of air through a stain detector tube. The contaminant in the air reacts with a reagent in the tube to indicate the level of contamination in the air.

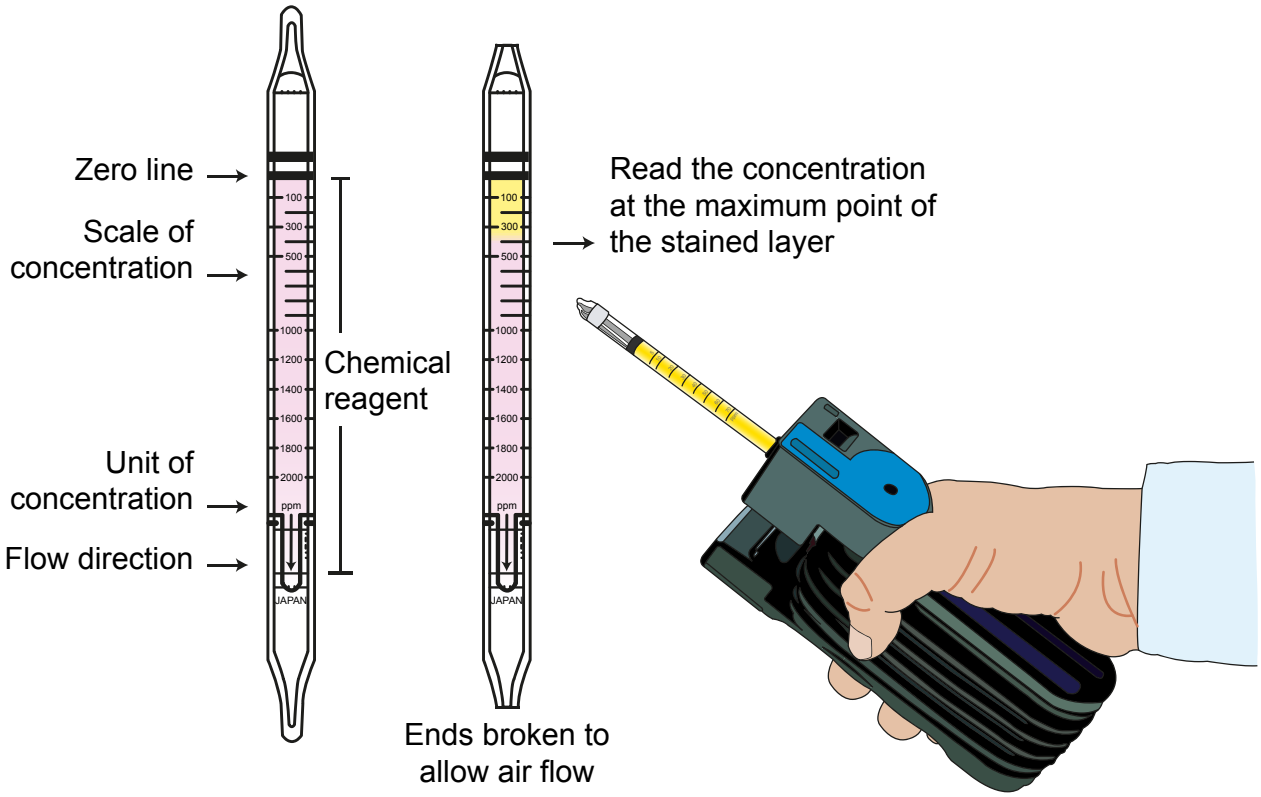


Figure 7.7: Hand bellows and stain detector tubes

This technique:

- takes a **grab sample**
- takes an **environmental sample**
- provides a **direct reading**
- uses an **active** method.

The strengths and weaknesses of using stain detector tubes are summarised in Table 7.4.

Strengths	Weaknesses
Relatively cheap	Substance specific – the correct tube must be specified for the suspected contaminant
Simple to use – no major costs for training or expertise	Only suitable for chemical contaminants (gases and fume)
Direct reading – immediate result	Not very accurate – variables include - • bellows efficiency • wrong number of pumps • cross sensitivity and date sensitivity of tubes • sampling point – proximity to contaminant
Provides an indication of the need for more sophisticated measurement	A grab sample may miss the presence of the contaminant

Table 7.4: Strengths and weaknesses of stain detector tubes

Personal dust monitoring

The personal monitoring *'sample train'* (See Figure 7.8) consists of:

- a *sampling head*, positioned in the wearers breathing zone (*e.g.* clipped to collar)
- connected with *tubing*
- calibrated portable medium flow *pump* (powered by rechargeable battery and clipped to a belt or carried in a holster.

For sampling total inhalable dust and IOM sampling head is used, to measure respirable dust a cyclone head is typically used, although a modified IOM head can do the job.

Note:

Different sampling heads can be used for sampling different contaminants such as asbestos fibres. Sorbent tubes may be used to capture gaseous contaminants..

A pre-weighed filter is placed in a sampling head. Air is drawn through the filter at a pre-set rate (*e.g.* two litres per minute) over a known period of time (*e.g.* a shift). The filter is then

taking to an approved laboratory for gravimetric analysis. The filter is re-weighed and the difference is the mass of contaminant in mg. this is divided by the volume of air sampled to give the daily exposure in mg/m³.

Laboratory techniques such as gas chromatography can be used to identify the chemical composition of the contaminant.

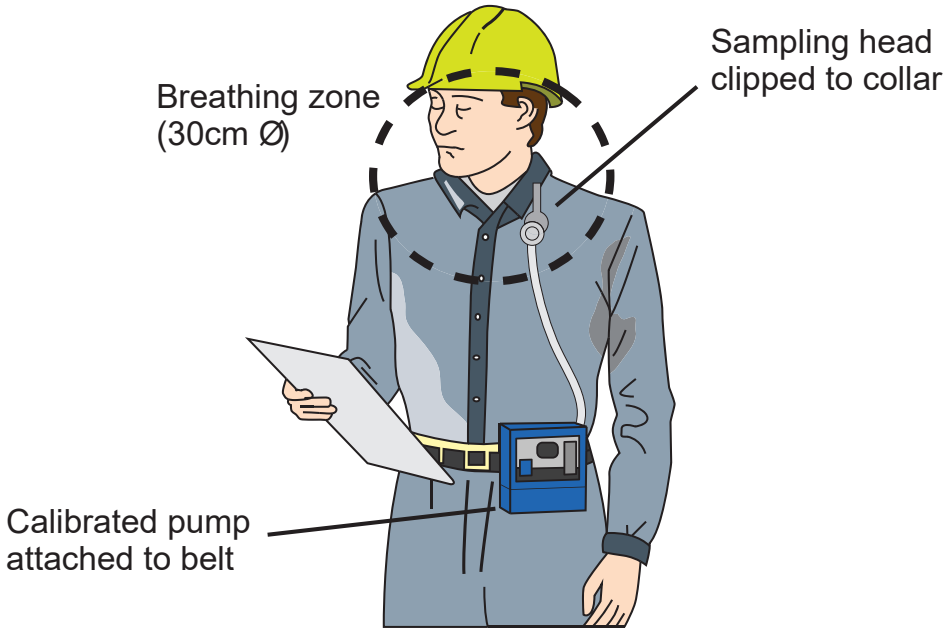


Figure 7.8: Personal sampling apparatus

This technique:

- takes a *long term sample*
- uses a *personal sampler*
- provides an *indirect reading*
- *actively* samples the air.

The strengths and weaknesses of personal dust sampling are summarised in Table 7.5.

Strengths	Weaknesses
Accurate	Expensive
Indicates the workers actual exposure during real work activity	Requires expertise to set up
Allows direct comparison to workplace exposure limits (WEL)	Time consuming (sample to lab for analysis)
	May be tampered with by wearer

Table 7.5: Strengths and weaknesses of personal dust sampling

7.3 Occupational exposure limits

As indicated in **Section 7.1,** occupational exposure limits (OEL) help protect the health of workers.

An OEL is the maximum concentration of an airborne substance averaged over a reference period (referred to as a time-weighted average – TWA) to which employees may be exposed by inhalation.

Substances with OEL's may be assigned *short-term exposure limits* (STELs) or *long-term exposure limits* (LTELs).

STELs have 15 minute reference periods and are intended to protect against acute adverse health effects arising from brief exposures to the substance.

LTELs have 8 hour reference periods is intended to control health effects arising from prolonged or accumulated exposure by restricting the total intake by inhalation over one or more work shifts. A *'standard shift'* is deemed to be 8 hours. Further calculation is therefore necessary where the *'shift length'* / exposure period is different.

Example WEL (from EH40)

Details of international occupational exposure standards can be obtained from the European Agency for Health and Safety at Work (Eu-OSHA) website at - http://osha.europa.eu/en/topics/ds/oel/nomembers.stm

Tables 7.6 to 7.9 present comparable information for workplace exposure limits (WEL) from the UK and threshold limit values (TLV) from the USA.

Substance	CAS number	WEL				Comments
		LTEL (8 hour)		STEL (15 minutes)		
		ppm	mg/m^3	ppm	mg/m^3	
Acetone	67-64-1	500	1210	1500	3620	
Benzene	71-43-2	1	3.25			Carc Sk
Carbon monoxide	630-08-0	20	23	100	117	BMGV
		30	35	200	232	Underground mining and tunnelling only until 21/08/2023
Chromium (VI) compounds as Cr	7449-47-3 (Chromium)		0.05			Carc Sen BMGV

Table 7.6: Example WELs

Table 7.7 explains the annotations

Annotation	Explanation
CAS number	A unique numerical identifier assigned by the Chemical Abstracts Service to every chemical described in the open scientific literature.
ppm	Parts per million by volume – used to express the limits for volatile substances.
mg/m^3	Milligrammes per meter cubed – Used to express concentrations of airborne particles (fume, dust etc.).
fibres/ml	Fibres per millilitre of air – use to express concentrations of fibres (*e.g.* man-made mineral fibres – MMMF).
Carc	Capable of causing cancer and/or heritable genetic damage.
Sk	Can be absorbed through skin. The assigned substances are those for which there are concerns that dermal absorption will lead to systemic toxicity
Sen	Capable of causing occupational asthma.
BMGV	Biological monitoring guidance value – Non statutory standards based on a relationship between biological concentrations and health effects. Listed in table 2 of EH40.

Table 7.7: EH40 Annotations

Note:

From December 2011 extensive Carc, Sen and Sk notations are no longer provided. Notations are now only applied to substances identified in the IOELV directives highlighted in Section 7.1.

Substance [CAS No.] (Documentation date)	Adopted Values				TLV Basis
	TWA	STEL	Notations	MW	
Acetone [6764-1] (1996)	500ppm	750ppm	(A4); BEI	58.05	(URT & eye irr; CNS impair; haematologic eff)
Benzene [71-43-2] (1996)	0.5ppm	2.5ppm	Skin; A1; BEI	78.11	Leukaemia
Carbon monoxide [630-08-0] (1989)	25ppm	–	BEI	28.01	COHb-emia
Chromium, [7440-47-3] and inorganic compounds, as Cr (1991) Metal and Cr III compounds	0.5 mg/ m^3	–	A4	Varies	URT & skin irr
Water-soluble Cr VI compounds	0.05 mg/ m^3	–	A1; BEI	Varies	URT irr; cancer
Insoluble Cr VI compounds	0.01 mg/ m^3	–	A1	Varies	Lung cancer

Table 7.8: Example TLVs

Notation	Explanation
A1	Confirmed human carcinogen
A2	Suspected human carcinogen
A3	Confirmed animal carcinogen with unknown relevance to humans
A4	Not classifiable as a human carcinogen
A5	Not suspected as a human carcinogen
BEI (Biological Exposure Index)	Guidance values for assessing biological monitoring results. BEIs® represent the levels of determinants that are most likely to be observed in specimens collected from healthy workers who have been exposed to chemicals to the same extent as workers with inhalation exposure at the Threshold Limit Value
COHb	Carboxyhaemoglobin
irr	Irritant
MW	Molecular Weight
Skin	Significant contributions to overall exposure by cutaneous route, mucous membranes or eyes by vapor or direct skin contact
SEN	Potential for the agent to produce significant sensitization, as confirmed by human or animal data
TWA (Time Weighted Average)	Average exposure on the basis of a 8h/day, 40h/week work schedule
STEL (Short-term exposure limit)	Spot exposure for a duration of 15 minutes, that cannot be repeated more than 4 times per day
URT	Upper Respiratory Tract

Table 7.9: TLV Notations and Explanations

Criteria for setting occupational exposure limits

OELs are set at levels which are either:

- the level at which no adverse effects on human health would be expected to occur based on the known and/or predicted effects of the substance
- a level corresponding to what is considered to represent good control, taking into account the severity of the likely health hazards and the costs and efficacy of control solutions.

OEL's and control of exposure

Where prevention of exposure to substances hazardous to health is not reasonably practicable adequate controls must be implemented.

Control of exposure to substances hazardous to health can only be considered adequate if:

- the principles of good practice for the control of exposure to substances hazardous to health have been applied
- workplace exposure limits have not been exceeded
- for carcinogens and sensitisers exposure is reduced to as low a level as is reasonably practicable.

An OEL or other exposure standard should not normally be exceeded. If it is, the employer should check the continuing effectiveness of the control measures.

Limitations to the application of exposure limits

The exposure limits relate to personal monitoring.

Working conditions which impose additional stress on the body, such as high temperatures, pressures and humidity, may increase the toxic response to a substance.

Inhalation may not be the sole route of entry into the body. Some substances have the ability to penetrate intact skin and become absorbed into the body, thus contributing to systemic toxicity.

7.4 Control measures

Employers are required to prevent employees' exposure to hazardous substances so far as is reasonably practicable and where prevention is not reasonably practicable to implement adequate controls.

Principles of good practice

The principles of good practice should be applied in all circumstances and a combination of controls will often be necessary to best protect the health of employees. These are:

1. design and operate processes and activities to minimise emission, release and spread of substances hazardous to health
2. take into account all relevant routes of exposure
3. ensure control measures are proportionate to the health risk
4. choose the most effective and reliable control options to minimise the escape and spread of hazardous substances
5. where adequate control cannot be achieved by other means, provide, in combination with other control measures, suitable personal protective equipment (PPE)
6. check and regularly review control measures to ensure their continuing effectiveness
7. inform and train all employees on the hazards and risks and the control measures developed to minimise the risks
8. ensure that the introduction of control measures does not increase the overall risk to health and safety.

Priority should be given to controls that contain or minimise the release or spread of hazardous substances in the workplace.

This requires the application of a hierarchy of control measures – **ERIC SP**

- **Eliminate** the hazard
- **Reduce** exposure or risk
- **Isolate** people from the hazard
- **Control** exposure to the hazard
- **Safe Systems of Work**
- **Personal Protective Equipment (PPE)**

Hierarchy of control measures – ERIC SP

Eliminate the hazard

The use or production of hazardous substances hazardous may be eliminated by:

- *changing* the method of work so that the operation giving rise to the exposure is no longer necessary
- *modifying* a process to eliminate the production of a hazardous by-product or waste product
- *substituting* wherever reasonably practicable, a non-hazardous substance which presents no risk to health where a hazardous substance is used intentionally.

Reduce the exposure or risk

Where it is necessary to use a hazardous substance efforts should be made to significantly reduce exposure and risks to employees health by *substituting*:

- an alternative less hazardous substance
- a different form of the same substance
- a different process.

Isolate people from the hazard

- totally enclosed process and handling systems
- plant or process changes to minimise the generation of hazardous substances and to contain hazardous substances within the plant.

Control exposure to the hazard

Overall exposure can be controlled by reducing, to the minimum required for the work concerned – the number of employees subject to the exposure, and the level and duration of exposure, and the quantities of hazardous substances present in the workplace.

Note:

Further notes on LEV and General Ventilation follow this section:

Working environment controls such as appropriate levels of general ventilation, and engineering controls such as LEV will also help to control workers exposure to airborne contaminants.

Safe systems of work

A safe system of work is:

'a formal procedure which results from a systematic examination of a task in order to identify all the hazards. It defines safe methods to ensure that hazards are eliminated or risks minimised.'

There are various approaches to systematically examining a task. The ***'4Ps'*** is one possible approach to ensure that all areas of work activity and risk creation are addressed (See Table 7.10).

Premises:	Includes:
	• Cleanliness and housekeeping arrangements
	• Personal hygiene facilities including:
	  • washing and toilet facilities
	  • storage and laundering of contaminated clothing
	  • clean areas for eating and drinking.

Plant and substances:	Systems to ensure the safe handling, storage, transport and disposal of hazardous substances and waste containing such substances.

Procedures:	The design of all jobs and work procedures to:
	• minimise generation of hazardous substances
	• reduce people's exposure time
	• minimise the number of people exposed
	• and to ensure the work is done safely in all areas including:
	  • operating procedures
	  • maintenance procedures
	  • cleaning procedures
	  • emergency response procedures.

People:	• health screening to ensure appropriate placement • monitoring of exposure • systems to reduce duration and frequency of exposure • ongoing health surveillance • training and supervision (competence).

Table 7.10: 4P – for safe system of work

Personal Protective Equipment (PPE)

Note:

This material was covered in **Element 3**.

Respiratory Protective Equipment (RPE)

There are two broad categories of RPE – respirators and breathing apparatus (BA). Respirators work by filtering contaminants out of the air so that the wearer breathes clean air. BA works by delivering a supply of breathable air from a uncontaminated source.

The key factors in selecting appropriate RPE are:

- the level of oxygen present in the air to be breathed
- the presence of toxic chemicals that may pose an imminent risk to life.

Only BA should be specified where the level of oxygen in the air is less than 20% or if there is an imminent risk to life.

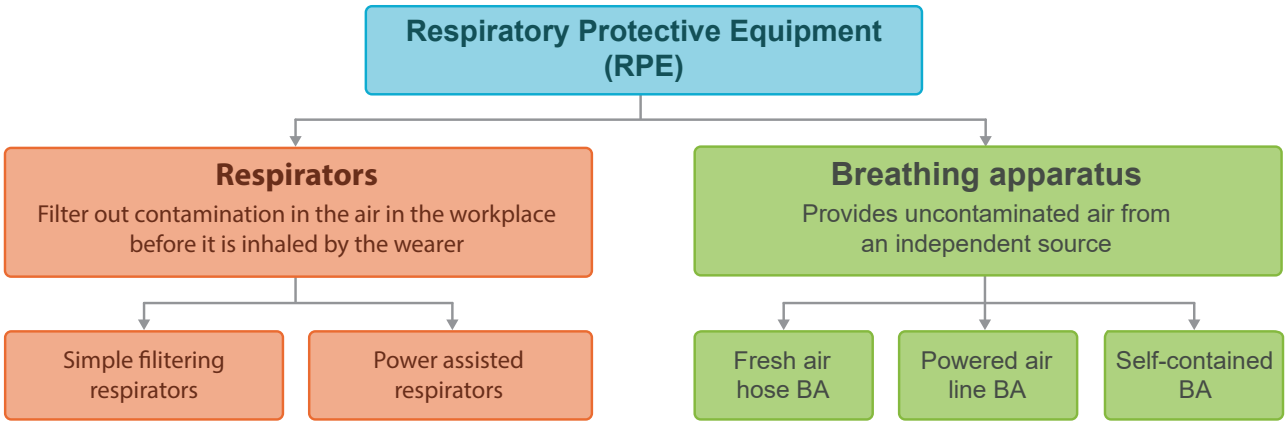


Figure 7.9: Main categories of RPE

Figure 7.10: Types of respirator and BA (HSG53 2005)

Respirators

Simple filtering respirators range from simple disposable paper dust masks providing a low level of orinasal (nose and mouth) protection against larger particulates (dust) to cartridge type respirators which may be half mask (orinasal) or full face mask and may use one or two exchangeable filter cartridges that must be carefully specified for known contaminants.

Power assisted respirators use hoods, helmets, visors or blouses with a battery powered filter unit. They achieve a high level of protection as in addition to the filtration unit the positive airflow to the breathing zone prevents the ingress of contaminated air. The cooling effect of the airflow can also improve worker comfort.

Breathing Apparatus (BA)

Breathing apparatus (BA) relies upon a supply of fresh air, either:

- from an *air hose* whose outlet is in an uncontaminated atmosphere and relies on the operator's lung power to draw in the fresh air
- from an *airline* using a compressor to provide a powered supply of filtered breathable air
- *self-contained breathing apparatus*, which may be open or closed circuit.

Open circuit systems supply air to the wearer from a cylinder either worn on a back pack or from a remote location.

Closed circuit systems remove excess carbon dioxide from exhaled air which is then re breathed by the wearer. This type of apparatus is generally only used for emergency self-rescue purposes.

Assigned Protection Factor (APF)

The APF is the level of respiratory protection that can realistically be expected to be achieved in the workplace by 95% of adequately trained and supervised wearers using a properly functioning and correctly fitted respiratory protective device.

It is calculated, under test conditions by dividing the level of air borne contamination by the level that would be breathed in (*i.e.* after the RPE has done its job). If there were 50 mg/m^3 of contaminant in the air and $5mg/m^3$ got passed the RPE the APF would be 50/5 = 10.

The APFs for specific types of RPE are detailed in BS EN 529: 2005. A filtering half mask (Class FF P1) has an APF of 4, whereas a self-contained open circuit compressed air breathing apparatus with positive pressure demand has an APF of 2000.

The minimum protection required (MPR) from specific RPE can be calculated by measuring the workplace concentration outside the face piece of the RPE and dividing it by the maximum allowable concentration inside the face piece of the RPE (*i.e.* the WEL).

$$\text{MPR} = \frac{\text{workplace concentration of contaminant outside RPE facepiece}}{\text{maximum allowable concentration inside the RPE facepiece (WEL)}}$$

To ensure an appropriate level of protection the APF of the selected equipment should be higher than the calculated MPR. The higher the APF the safer the wearer, assuming the RPE fits will and is performing effectively.

Fit testing

The performance of a tight fitting face piece (*i.e.* full-face mask, a half facemask, or a filtering face piece) relies heavily on the goodness of fit of the face piece to the wearer's face. An inadequate fit will significantly reduce the protection provided to the wearer.

Fit testing is required to ensure that selected RPE can provide adequate protection for the individual wearer

There are two basic types of RPE fit testing – qualitative and quantitative.

Qualitative fit testing is a simple pass/fail test based on the wearer's subjective assessment of the leakage, via the face seal region, of a test agent. If the wearer can detect the test agent (either a bitter or sweet tasting aerosol, or an odorous compound) the fit test is failed.

Quantitative fit testing provides a numerical measure of the fit that is called a fit factor. These tests give an objective measure of face fit. They require specialised equipment and are more complicated to carry out.

Fit test reports should be available for all employees who wear RPE incorporating tight fitting face pieces. The records should be retained by the employer and kept available for inspection on request.

Eye/face protection

Eye/face protection can be specified to protect against chemical and biological hazards including:

- chemical splashes
- fine dusts and powders
- fumes, vapours and gases
- biological agents/viruses.

Suitable styles of eye protection are shown in Table 7.11:

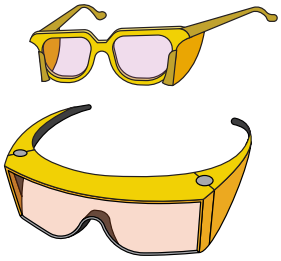
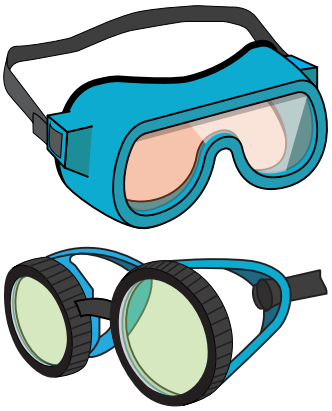
Type	Picture	Description
Safety spectacles		Will afford some protection against chemical splashes, protection is improved with side shields. Eye shields may be worn over corrective spectacles.
Safety goggles		Cup type (with separate eye coverings) or box type (with a single covering). Provide a higher level of protection than spectacles – as the eyes are enclosed the afford protection against fine dusts, gases and vapours, and biological agents. May be less comfortable and prone to misting.
Face shields		Protects the whole face from impact or chemical splashes but offers little protection against dust and fume.

Table 7.11: Eye / face protection

Protective clothing

Gloves, gauntlets, aprons, leggings, footwear and gaiters can all be specified to protect against chemical splashes.

Table 7.12 shows recommended glove materials for different chemical hazards.

Chemical group	Glove material					
	Natural rubber	Nitrile rubber	Neo-prene	PVC	Butyl	Viton
Weak acids/alkalis	✓	✓	✓	✓		
Oils		✓				
Chlorinated hydrocarbons						✓
Aromatic solvents						✓
Aliphatic solvents		✓				✓
Strong acids					✓	
Strong alkalis			✓			
PCBs						✓

Table 7.12: Glove materials for chemical hazards

Applications/principles of capture

A local exhaust ventilation (LEV) system takes contaminants (dusts, mists, gases, vapour or fumes) out of the air so that they can't be breathed in. Properly designed LEV:

- takes contaminated air away from people
- cleans the air (if necessary) and gets rid of the contaminants safely.

For LEV to work effectively the hood has to be carefully matched to the source that needs to be controlled.

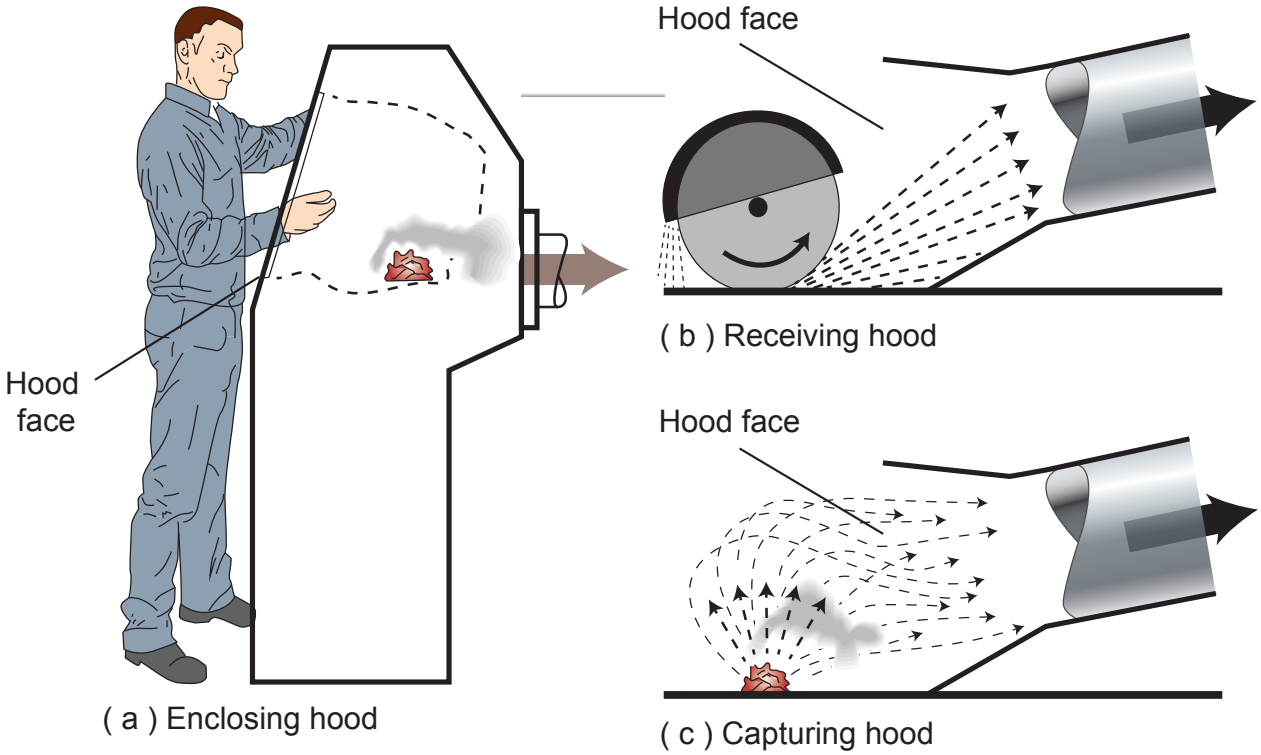


Figure 7.11: Types of hood

Enclosing hoods are the most effective type of hood. Examples are shown in Table 7.13.

Type of enclosure	Description	Example(s)
Full enclosure	Process is completely enclosed	Glove box
Roomenclosure/ Enclosing room	The operator and the process are enclosed	Abrasive-blasting rooms Paint-spraying booth
Partial enclosure	Contains the process with openings for material and/or operator access	Fume cupboard

Table 7.13: Types of enclosure

Receiving hoods are designed to take advantage of the speed and direction of the contaminant cloud as generated by the process. A canopy hood over a hot process is a classic receiving hood, taking advantage of thermal currents to take the contaminant away from the workplace. Receiving hoods can be fixed or moveable.

Capturing hoods (captor or capture hood) are the most common type of LEV hood. A capturing hood has to generate sufficient airflow at and around the source to *'capture'* and draw in the contaminant laden air. Hoods can be fixed or moveable.

Examples include rim/lip extraction (slot), downdraught tables or benches and low volume high velocity (LVHV) hoods.

System components

The basic components of an LEV system are:

a. An inlet (*e.g.* a hood or enclosure) to collect and contain the contaminant close to its source

b. ductwork, to convey the contaminant away from the source

c. a filter/air-cleaner to remove the contaminant from the extracted air-stream (*Note:* the filter should normally be located before the fan)

d. a fan or other air-moving device to provide the necessary airflow

e. further ductwork to discharge the cleaned air to the outside atmosphere at a suitable point.

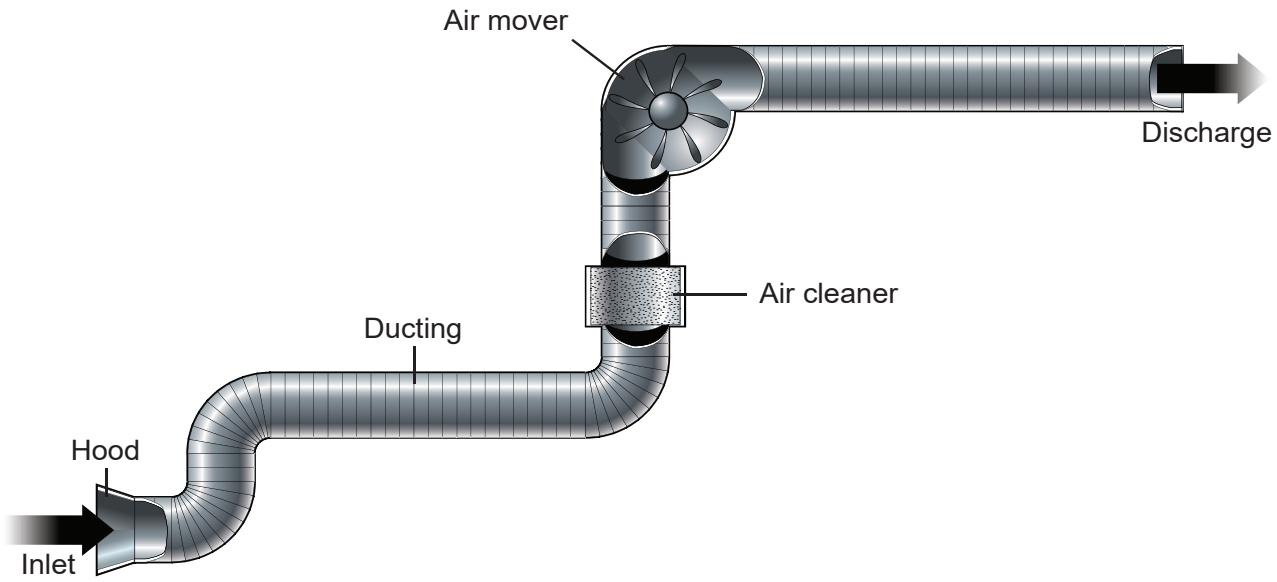


Figure 7.12: Local exhaust ventilation system

Factors reducing effectiveness

The following factors can reduce the effectiveness of LEV:

- poor design – inappropriate inlet for type and size of contaminant cloud, or underpowered fan unable to capture contaminated air
- poor use – system not switched on when needed, or inappropriate positioning of moveable hood
- unauthorised modification – can imbalance a system an adversely affect air flows
- inadequate maintenance – damaged ducting, congested filters and damaged fan blades will compromise the effectiveness of the LEV
- changes of work activity – generating more contaminant than the LEV was designed to cope with.

Requirements for inspection

How often the LEV system should be checked depends on how complicated the system is, how likely it is to fail, and the consequences if it does.

Regular inspections should be made of the following areas:

- moving parts that may wear, such as fan bearings or filter shakers
- non-moving parts, such as hoods, ductwork and seals (which can suffer physical or chemical damage and wear)

- parts that deteriorate with use, such as filters or flexible ducting
- items that need regular attention, such as filters that need replacing, or removing sludge from a wet scrubber.

This may involve daily operator checks and periodic checks by managers.

Thorough examination and test

LEV systems require an annual thorough examination and test by a competent person to make sure it works well and protects the employees.

Systems controlling more critical or high-hazard processes require more frequent thorough examination and testing.

The thorough examination includes airflow and pressure measurements, checks on control effectiveness and, possibly, exposure measurement. It tests the LEV against the performance recorded in the commissioning report.

Environmental considerations

The use of LEV can result in neighbour complaints regarding fan noise, odour and visible fume. Waste arising from contaminated filters or water scrubbers must be disposed of responsibly.

General (dilution) ventilation

General ventilation or *'dilution'* ventilation is a term used to define the flow of air into and out of a working area, so that any contaminants are diluted by adding some fresh air. It can be provided by:

- natural ventilation which relies on wind pressure and temperature differences to move fresh air through a building and is usually not fully controllable
- *'forced'* or mechanical ventilation which uses mechanical supply and/or extraction to provide fresh air and is controllable.

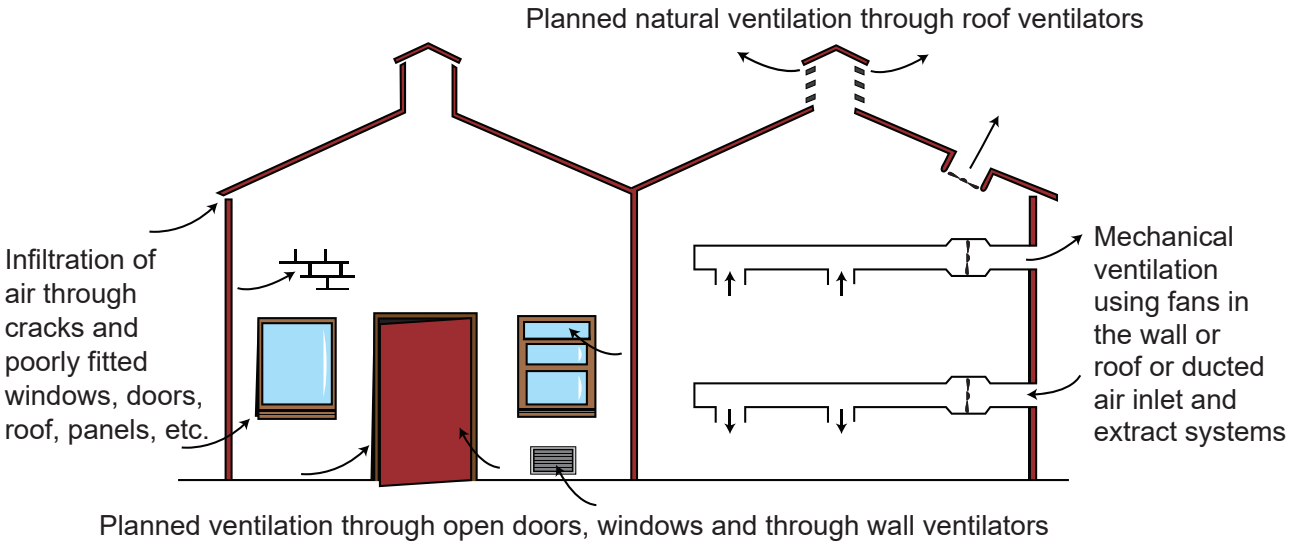


Figure 7.13: General ventilation

General ventilation:

- provides fresh air
- removes excess heat or, provides heat to maintain a comfortable temperature
- dilutes and removes offensive odours
- dilutes any contaminants caused by workplace activities.

Health surveillance and biological monitoring

Health surveillance is the ongoing assessment and/or medical examination of an employee at regular intervals to determine the employees' health state in the context of exposure to occupational health hazards.

Examples of Health Surveillance include:

- health questionnaires
- lung function tests
- skin inspections
- blood/urine analysis.

The benefits of health surveillance include:

- ensuring the early identification and treatment of an occupational disease
- provision of statistics relating to the health of the workforce
- a feedback mechanism for risk assessments, to establish whether control measures are effective
- provision of evidence of due diligence and relevant information for defending legal action.

Biological monitoring is a subset of health surveillance which involves the measurement and assessment of workplace agents or their metabolites (substances formed when the body converts the chemical) in exposed workers. Measurements are made either on samples of breath, urine or blood, or any combination of these.

Biological effect monitoring is the measurement and assessment of early biological effects in exposed workers caused by absorption of chemicals.

Further control of asthmagens, carcinogens and mutagens

- *asthmagens* (respiratory sensitisers) are chemicals that are capable of causing or increasing the incidence of occupational asthma
- *carcinogens* are chemicals that may cause cancer or increase its incidence
- *mutagens* are chemicals that induce heritable genetic defects or increase their incidence.

Exposure to hazardous substances should be reduced proportionate to the health risks. As the consequences of exposure to asthmagens, carcinogens and mutagens are potentially so severe and there is limited scientific knowledge on safe levels exposure should always be reduced *so far as is reasonably practicable*.

Additional safeguards specified for controlling the risk of exposure to carcinogens and mutagens include:

- totally enclosing the process and handling systems (unless not reasonably practicable)
- prohibiting eating, drinking and smoking in areas that may be contaminated by carcinogens or mutagens
- cleaning floors, walls and other surfaces regularly and as necessary
- clearly designating areas and installations that may be contaminated by carcinogens or mutagens and posting warning signs
- storing, handling and disposing of carcinogens or mutagens safely, including using closed and clearly labelled containers.

Asbestos

Asbestos is a naturally occurring mineral (fibrous silicate) which, because of its various useful properties (thermal insulation, fire resistance, electrical insulation and high tensile strength), has been in large scale use for about 150 years.

Three main types have been used in Great Britain:

- crocidolite (blue)
- amosite (brown)
- chrysotile (white).

Crocidolite and amosite are *'amphibole'* asbestos (amphiboles are a group of minerals with similar crystal structures containing a silicate chain and combinations of sodium, calcium, magnesium, iron and aluminium), whereas chrysotile asbestos (a hydrated magnesium silicate) is *'serpentine'* asbestos.

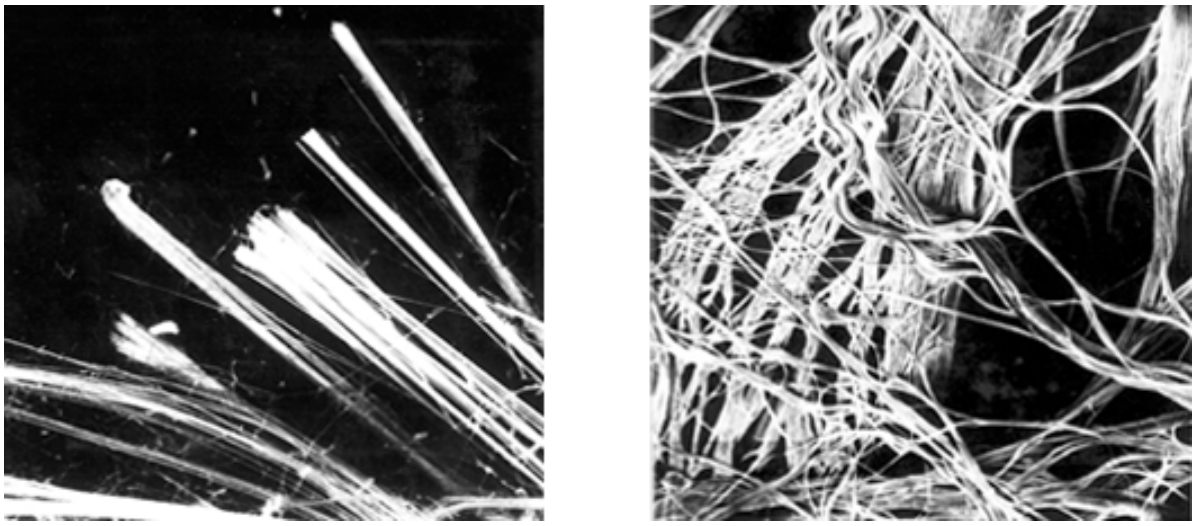


Figure 7.14: Asbestos fibres – Crocidolite (left) and Chrysotile (right)

Exposure to amphibole asbestos poses a greater health hazard than exposure to chrysotile, but all types can cause asbestos-related diseases.

The use of new materials containing blue and brown asbestos was banned in 1985. In 1999 the new use of building materials containing white asbestos was also banned.

Use of asbestos

Asbestos was extensively used as a building material in the UK from the 1950s through to the mid-1980s.

The most common uses of asbestos in buildings were:

- loose packing between floors and in partition walls
- sprayed (*'limpet'*) fire insulation on structural beams and girders
- lagging on pipe-work, boilers, calorifiers, heat exchangers etc.
- asbestos insulation board (AIB) in ceiling tiles, partition walls, soffits, service duct covers, fire breaks, heater cupboards, door panels, lift shaft linings, fire surrounds
- asbestos cement (AC) in roof sheeting, wall cladding, walls and ceilings, bath panels, boiler and incinerator flues, fire surrounds, gutters, rainwater pipes and water tanks.

Asbestos insulation board (AIB)

Unscrewing AIB ceiling Boards

Asbestos lagging rope and lagging

Asbestos cement down-pipe hopper and sheeting

Sprayed "limpet" asbestos

Damaged asbestos lagging

Figure 7.15: asbestos in use

The problem

Asbestos containing materials (ACM) in good condition are safe unless asbestos fibres become airborne, which happens when materials are damaged.

Working on or near damaged asbestos-containing materials or breathing in high levels of asbestos fibres, (hundreds of times environmental levels) greatly increases the chance of getting an asbestos-related disease.

There are four main diseases caused by asbestos:

- mesothelioma (which is always fatal)
- lung cancer (almost always fatal)
- asbestosis (not always fatal, but very debilitating)
- diffuse pleural thickening (not fatal).

Asbestos related diseases are responsible for around 4 000 deaths a year.

The duty to manage

The person in control of maintenance activities in non-domestic premises, (*e.g.* occupier, landlord, or managing agent) is required to manage the risk from asbestos in the premises, and to ensure that a suitable and sufficient assessment is carried out as to whether asbestos is or is liable to be present in the premises.

The duty to manage requires the duty holder to:

- take reasonable steps to find out if ACM are present and if so establish the amount, its condition and location
- presume materials contain asbestos unless there is strong evidence that they do not
- make, and keep up-to-date, records of the location and condition of the ACM and presumed ACM
- assess the risk of anyone being exposed to fibres from the materials identified
- prepare a plan that sets out in detail how the risks from these materials will be managed
- take the necessary steps to put the plan into action
- periodically review and monitor the plan and the arrangements to act on it so that the plan remains relevant and up-to-date
- provide information on the location and condition of the materials to anyone who is liable to work on or disturb them.

There is also a requirement on anyone to co-operate as far as is necessary to allow the duty holder to comply with the above requirements.

ACM surveys

There are two types of survey for ACM: a management survey, and a refurbishment/demolition survey.

The management survey

The purpose of the *'management survey'* is to ensure that ACM are effectively managed during the normal occupation and use of premises.

In simple and straightforward premises the survey may be undertaken by the duty holder, otherwise, a surveyor should be employed.

The survey must locate ACM that could be damaged or disturbed by normal activities, by foreseeable maintenance, or by installing new equipment. It will involve minor intrusion and disturbance of presumed ACM.

The survey will confirm the condition of ACM and establish whether any remedial works are necessary. It also informs the asbestos register and should be used to prevent future accidental disturbances of ACM.

Refurbishment/demolition survey

The Refurbishment/demolition survey is required where the premises, or part of it, need upgrading, refurbishment or demolition.

The survey involves destructive inspection and sampling of ACM and must identify all ACM before any structural work begins.

The area to be surveyed must be vacated for the survey, and certified as *'fit for reoccupation'* after the survey.

If any ACM require sealing, encapsulation or removal, a licensed contractor must be used, unless the materials are lower risk (*e.g.* asbestos cement) then an unlicensed but competent contractor may undertake the work.

Control measures before and during work with asbestos

- Determine the type and condition of the asbestos.
- Carry out a risk assessment to ascertain the extent of exposure and who might be at risk. Decide what work methods are necessary to provide effective control of the risks including measures to ensure the asbestos does not spread.
- Decide if the work needs to be carried out by a licensed contractor based on the type and condition of the ACM, and the duration of the work:
    - all work with sprayed asbestos coatings and asbestos lagging and most work with asbestos insulation and asbestos insulating board (AIB) require a licence.
- If the work is not licensable, decide if the work needs to be notified:
    - if it doesn't need a licence, maintenance work on or around ACMs can be done with the appropriate controls in place in accordance with specific task guidance sheets (HSG210 – Asbestos Essentials)
    - Some non-licensed work also has additional requirements, *i.e.* notification of work, medical surveillance and record keeping – known as notifiable non-licensed work (NNLW).
- Ensure those carrying out the work are suitably trained.
- Draw up a suitable plan covering:
    - scope of the work as identified by the risk assessment
    - address and location where the work is to be carried out
    - methods to be used for the work with the asbestos
    - prevention and control measures for handling and disposal
    - type of equipment, including PPE
    - procedures for protection and decontamination.
- Typical control measures required for work with asbestos are:
    - sealed working enclosure connected directly to a decontamination unit (DCU) under negative pressure
    - appropriate stripping techniques (wet stripping by injection, spraying or dry stripping using wrap-and-cut, glove-bags, shadow vacuuming)
    - appropriate hygiene and decontamination facilities
    - suitable RPE that has been fit tested
    - suitable PPE (disposable coveralls, gloves, footwear etc.)
    - suitable bagging and disposal of waste
    - air monitoring.

Silica

Exposure

Many types of stone contain silica and produce silica dust known as Respirable Crystalline Silica (RCS). RCS is also known as respirable-quartz, cristobalite, or *'free silica'*.

Crystalline silica is present in substantial quantities in sand, sandstone and granite, and often forms a significant proportion of clay, shale and slate. It can also be found in chalk, limestone and other rock and soil, though this is unusual. Products such as concrete and mortar also contain crystalline silica.

Activities which can expose workers or members of the public to silica dust include:

- stone masonry
- facade renovation
- blast cleaning of buildings, especially using sand
- many demolition processes
- concrete scabbling, cutting or drilling
- tunnelling.

Health effects

Breathing in the very fine dust of crystalline silica can lead to the development of silicosis (scarring of the lung tissue and breathing difficulties).

Silicosis may be *acute* resulting in rapidly progressive breathlessness and death within a few months of onset or more commonly – *progressive*.

Progressive silicosis causes fibrosis (hardening or scarring) of the lung tissue and a loss of lung function. The effect continues to develop after exposure has stopped and is irreversible. Sufferers often die prematurely due to heart failure. Lung cancer may also occur as a progression of fibrosis.

Control measures

Elimination by substituting non silicate materials *e.g.* using non-silica grits for blasting.

Eliminating or reducing dust levels by designing out the need for dust generating activities such as scabbling, cutting or drilling concrete.

Controlling exposure to silica dust by dust suppression techniques (wet working) and local exhaust ventilated tools to remove the dust at source.

Respiratory protective equipment requires careful selection. For the dustiest processes, positive pressure or airline breathing apparatus will probably be necessary.

Good hygiene controls – washing facilities and laundry arrangements.

Wood dust

Exposure

Wood dust consists of tiny particles of wood produced during the processing and handling of wood, chipboard, hardboard and other composite boards.

Activities likely to produce high dust levels include:

- machining operations, particularly sawing, routing and turning
- sanding, by machine and by hand
- using compressed airlines to blow dust off furniture and other articles before spraying
- hand assembly of machined/sanded components
- any operations involving composite boards, *e.g.* medium-density fibreboard (MDF)
- the bagging of dust from dust extraction systems
- factory cleaning, especially if compressed airlines are used for blowing dust from surfaces etc.

Health effects

The following health problems are among the effects associated with exposure to wood dust:

- dermatitis and other skin disorders
- rhinitis (inflammation of nasal mucous membranes/runny nose)
- asthma
- nasal cancer.

Control measures

Control measures include:

- changing a process or method of work to reduce the generation of dust to a minimum
- providing dust control equipment *e.g.* local exhaust ventilation at woodworking machines
- maintaining LEV plant and equipment in efficient working order
- damping the work area down
- vacuuming instead of sweeping
- limiting the amount of time that personnel are exposed
- respiratory protective equipment where necessary
- other PPE, such as eye protection, overalls and gloves, where necessary
- arrangements for laundering dusty work clothes
- good washing facilities with hot and cold water, soap and towels.

Blood Borne Viruses (BBVs)

Exposure

BBVs are viruses that some people carry in their blood and which may be spread to another person, whether the carrier of the virus is ill or not. The main BBVs of concern are:

- hepatitis B virus (HBV), hepatitis C virus and hepatitis D virus
- human immunodeficiency virus (HIV).

In the workplace, direct exposure can happen through accidental contamination by a sharp instrument, such as a needlestick (or sharps) injury. Infected blood may also spread through contamination of open wounds, skin abrasions, skin damaged due to a condition such as eczema, or through splashes to the mucous membranes of the eyes, nose or mouth.

Healthcare workers are at greatest risk from needlestick injuries are those within the healthcare sector, but others may also be at risk including: prison workers, police officers, probation officers, social workers, funeral directors, and body piercers/tattooists.

Health effects

Hepatitis B virus (HBV), hepatitis C virus and hepatitis D virus all cause hepatitis, a disease of the liver. Human immunodeficiency virus (HIV) causes acquired immune deficiency syndrome (AIDS), which affects the immune system of the body.

Control measures

There is an effective protective vaccine available for HBV, but not for any of the other BBVs.

In order to avoid occupational BBV infection, one has to prevent exposure to the infectious agent. HPA (Health Protection Agency) research has shown that whenever a needlestick injury was sustained whilst performing a procedure it would have been very difficult to prevent the injury. The majority of injuries are sustained after a procedure and during disposal. These are typically caused by failure to adhere to universal precautions and are predominantly avoidable.

The universal precautions recommend:

- hand washing after each patient contact and after contact with blood or body fluids
- appropriate PPE including:
    - disposable gloves
    - disposable plastic aprons/impermeable gowns
    - eye protection (visors, goggles, or safety spectacles) when blood etc might splash into the face
- covering any cuts or abrasions with waterproof plasters
- decontamination procedures
- immediate and safe disposal of sharps into appropriate, puncture-proof sharps bins
    - not overfilling sharps containers
    - never re-sheathing needles
- procedures for disposal of contaminated waste
- vaccination (where available).

Leptospirosis

Exposure

Two types of leptospirosis infection can affect workers in the UK:

- Weil's disease – transmitted to humans by contact with urine from infected rats
- Hardjo leptospirosis – transmitted from cattle to humans.

Anyone who is exposed to rats, rat or cattle urine or to foetal fluids from cattle is at risk.

Farmers are now the main group at risk for both Weil's disease and Hardjo leptospirosis. Vets, meat inspectors, butchers, slaughtermen, sewer workers, and workers in contact with canal and river water have all contracted leptospirosis in recent years.

Recreational water users such as canoeists, wind surfers, open water swimmers, jet skiers, pot-holers etc. are also at risk.

The route of entry through skin cuts and scratches or the mucous membranes of the mouth, throat and eyes after contact with infected urine or contaminated water.

Health effects

Some cases may be asymptomatic or present in the first phase with the abrupt onset of a flu-like illness, with a severe headache, chills, muscle aches, and vomiting. This phase may resolve without treatment.

In some cases a second phase occurs involving a return of fever, jaundice (yellow skin and eyes), red eyes, abdominal pain, diarrhoea, and a rash.

In more severe cases, there may be kidney failure or meningitis.

Generally, cases will recover fully within two to six weeks but some may take up to three months.

Control measures

There is no human vaccine available in the UK that is effective against leptospirosis. Doxycycline (200 mg weekly) may be effective as a prophylactic for high risk groups for short periods.

General control measures are:

- pest control to kill rat population
- covering all cuts and broken skin with waterproof plasters before and during work
- wearing protective clothing and gloves
- not touching rats or cattle with unprotected hands
- veterinary advice about the cattle infection
- washing hands after handling any animal or possibly contaminated materials before eating or drinking
- washing cuts and grazes immediately with soap and running water
- at-risk workers should be provided with, and be instructed to carry at all times, a workers card (yellow card) to help early diagnosis and treatment.

Recreational water users should:

- avoid stagnant, slow moving water
- wear protective footwear
- shower promptly after any submersion.

Legionella

Exposure

Legionellosis describes a group of diseases including Pontiac fever and Lochgoilhead fever and the most serious of which is Legionnaires' disease.

It is caused by the bacterium Legionella pneumophila and related bacteria that can be found naturally in environmental water sources. People catch Legionnaires' disease by inhaling small droplets of water containing the bacteria suspended in the air as an aerosol.

The following conditions increase the risk from legionella:

- a suitable temperature for growth, 20 to 45°C
- a source of nutrients for the organism such as sludge, scale, rust, algae, or other organic matter
- a way of creating and spreading breathable droplets, *e.g.* the aerosol created by a cooling tower, spa pool, or shower.

Health effects

Legionnaires' disease is a potentially fatal form of pneumonia which principally affects those who are susceptible because of age, illness, immuno-suppression or smoking. It occurs more frequently in men than women.

Most people exposed to legionella do not become ill, and Legionnaires' disease does not spread from person to person.

The symptoms of Legionnaires' disease are typically similar to those of flu:

- high temperature, fever and chills
- cough
- muscle pains
- headache.

In a bad case there may also be pneumonia, diarrhoea and signs of mental confusion.

Control measures

- elimination of wet cooling towers with dry air cooled systems
- designing water systems to discourage the growth of legionella bacteria (designing out dead ends, removing redundant pipework and other areas where water can stagnate)
- use biocides to treat the water to prevent or limit bacterial growth
- temperature control – in hot and cold water systems, store hot water >60°C and distributing > 50°C – and keep cold water <20°C if possible.

Cement

Exposure

Cement is made primarily of pulverised kiln dried limestone. It is widely used in the construction industry in materials such as mortar, plaster and concrete.

Health effects

Cement can cause ill-health as summarised in Table 7.14.

Skin contact with wet cement	Cement can cause both irritant and allergic dermatitis (NB both types can occur simultaneously). Irritant dermatitis is caused by mechanical irritation of the skin by cement particles. Allergic dermatitis occurs as a result of sensitisation to chromate (hexavalent chromium) in the cement. The chromate is absorbed through the epidermis and triggers an allergic reaction. Chromate is the most common cause of allergic dermatitis in men affecting up to 10% of construction workers, particularly plasterers, concreters and bricklayers. Once sensitised any future exposure, however small, may trigger dermatitis. Wet cement is alkaline. It can cause serious burns and skin ulcers if trapped against the skin. Splashes can also cause serious chemical burns to the eyes.
Inhalation of cement dust	Exposure to high levels of cement dust causes acute irritation of the nose and throat. Scabbling or concrete cutting can also produce high levels of silica dust which can cause silicosis.
Manual handling	Lifting and carrying cement bags, mixing mortar etc. can cause acute effects such as sprains and strains to the back, arms and shoulders. More serious chronic back injuries can result from continual lifting of heavy weights over time

Table 7.14: Cement – health effects

Control measures

- the use of cement can be eliminated at the design stage by specifying other bonding agents and surface finishes
- purchasing ready mixed concrete eliminates dust generation during mixing
- wet working and dust suppression (LEV at source) when cutting/drilling/scabbling concrete/cement products
- wearing protective clothing, including: overalls with long sleeves and long trousers, gloves where appropriate, and safety footwear/Wellington boots (care must be taken to avoid trapping cement against the skin)

- provision of good washing facilities with warm water, soap, and clean towels
- facilities for drying and cleaning contaminated clothing
- suitable health surveillance arrangements to check skin condition.

Carbon monoxide (CO)

Exposure

Carbon monoxide (CO) is a colourless, odourless, tasteless, poisonous gas produced by incomplete burning of carbon-based fuels, including gas, oil, wood and coal. It is a by-product of mining, smelting, foundry work, and petrochemical processes.

Health effects

Haemoglobin in the red blood cells bonds with carbon monoxide (in preference to oxygen) to create carboxyhaemoglobin resulting in a diminished capacity to carrying oxygen within the blood.

Early symptoms of carbon monoxide (CO) poisoning can easily be confused with food poisoning, *'flu'*, or tiredness. Symptoms include headaches, breathlessness, nausea, dizziness, collapse, loss of consciousness, tiredness, drowsiness, vomiting, chest pains, stomach pains, erratic behaviour and visual problems.

Prolonged exposure to high levels of CO can cause paralysis, brain damage and death.

Controls

Controls include:

- the use of gas safe registered heating engineers to install, service, modify, and maintain gas fired heating equipment
- ensuring that exhaust disperse to atmosphere
- working in well ventilated areas
- the use of CO alarms to provide early warnings.

Version 1.0 2019