NEBOSH National Certificate in Construction Health & Safety Unit NCC1

MANAGING & CONTROLLING HAZARDS IN CONSTRUCTION ACTIVITIES

ELEMENT 8: CHEMICAL AND BIOLOGICAL HEALTH - HAZARDS AND CONTROL

SAMPLE MATERIAL

(Material correct Autumn 2013)

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Forms, Classification and Health Risks from Exposure to Hazardous Substances

Key Information

- In construction activities, many different forms of chemical hazards occur – dusts, fumes, gases, mists, vapours and liquids. The form they are in can significantly affect how they might enter the body.
- Biological agents such as fungi, bacteria and viruses can be hazardous to health.
- Chemicals are classified according to their hazardous properties: toxic, harmful, irritant, corrosive or carcinogenic.
- There are differences between acute and chronic health effects of hazardous substances.

Exposure to chemical hazards can occur:

- Intentionally – by using chemicals in our work.
- Unintentionally – from spillages and accidents.

In either case, exposure has to be prevented, and where we can't prevent it, it must be controlled so that no harm is caused to those who may be exposed.

Exposure can lead to immediate health effects (e.g. carbon monoxide can cause asphyxiation) or even physical effects (battery acid can burn the skin).

Some hazardous substances can have both short-term and long-term effects, e.g. concrete or stone grinding dust can cause immediate coughing and respiratory distress, and can lead on to permanent lung damage from prolonged or repeated exposure.

Spillages can lead to unintentional exposure to hazardous substances

Forms of Chemical Agents

Chemicals may be in the form of a substance (a chemical element or compound) or a preparation (a mixture of substances). These exist in a variety of physical states and this will affect the way chemical hazards occur in construction activities. The physical forms of chemicals are:

- **Dusts** – small solid particles created by grinding, polishing, blasting, road sweeping and mixing materials (e.g. cement), which become airborne.
- **Fibres** – asbestos and other man-made mineral fibres (MMMF) have different characteristics from dust particles. Important dimensions are the length and diameter of the fibre and the length to diameter ratio.
- **Fumes** – fine solid particles which are created by condensation from a vapour (e.g. welding fume) given off in a cloud. Metallic fume is usually the oxide of the metal and is toxic.
- **Gases** – a gas is a formless chemical which occupies the space in which it is enclosed (e.g. carbon dioxide, acetylene).
- **Mists** – small liquid droplets (aerosol) suspended in the air, created by activities such as paint spraying.
- **Vapours** – the gaseous form of a liquid or solid substance at normal temperature and pressure (e.g. solvent vapours given off by acetone).
- **Liquids** – a basic state of matter; free flowing fluid (e.g. water at room temperature).

Forms of Biological Agents

Biological agents are micro-organisms. We will look at four types:

- **Fungi** – plant matter lacking chlorophyll and reproducing by spores. Examples include mushrooms, mould and yeasts. Fungal diseases can appear as asthmatic and/or influenza-type symptoms from inhaling dust or air contaminated by fungi, such as dry rot in roofs, or fungal infections such as athlete's foot.
- **Blue-green algae** (cyanobacteria) – can form on de-oxygenated waters. These algal blooms can be toxic to humans, causing liver damage, contact dermatitis, asthma, eye irritation, abdominal pain, etc. Main exposure is through skin/eye contact and ingestion. Construction activities near rivers, watercourses or reservoirs containing algal blooms should be avoided or access to such work environments restricted. The use of appropriate PPE will be required alongside good personal hygiene practices.

Jargon Buster

Dermatitis

Is a skin disease (also called eczema) in which the skin's surface protective layer is damaged, leading to redness/swelling of hands and fingers, cracking of skin and blisters on hands/fingers, flaking/scaling of skin and itching of hands/fingers with cracks.

Bad cases can cause absence from work. It can be reportable under **RIDDOR** in certain cases.

- **Bacteria** – single-cell organisms found in vast numbers in and on the human body. Some are harmless, some are beneficial (certain gut bacteria) and some cause diseases, e.g. Legionnaires' disease or Weil's disease (leptospirosis). Construction activities near waterways could pose a risk from Weil's disease.
- **Viruses** – very small infectious organisms that increase by hijacking living cells to reproduce and generate more viruses. Many cause disease, e.g. hepatitis and AIDS.

Main Classification of Hazardous Substances

Chemicals can be broadly classified in three types, i.e. those having:

- **Physico-chemical effects** – explosive, oxidising, highly flammable.
- **Health (toxicological) effects** – toxic, harmful, irritant, carcinogenic.
- **Environmental effects** – harmful to aquatic organisms, dangerous for the ozone layer.

Topic Focus

Chemicals hazardous to health are classified as:

- **Toxic** (or very toxic) – small quantities cause death or serious ill-health if inhaled, swallowed or absorbed via the skin.
- **Harmful** – may cause death or serious ill-health when inhaled, swallowed or absorbed through the skin in large doses.
- **Corrosive** – destroy living tissue on contact, such as sulphuric acid and hydrochloric acid in chemical cleaners, e.g. for masonry, brickwork.
- **Irritant** – cause inflammation of the mucous membranes (eyes and lungs) or skin from immediate, prolonged or repeated contact.
- **Carcinogenic** – may cause cancer (abnormal growth of cells in the body) when inhaled, swallowed or absorbed via the skin.

Examples of current hazard symbols are:

Topic Focus

Hazard Symbols - GHS

It is proposed that by 2015 all hazard symbols will be harmonised throughout the world to comply with the **Globally Harmonised System** (**GHS**). This will mean that the current orange and black labels will change to symbols of the type shown below.

The first symbol (carcinogen) is completely new; the other examples show a similar symbol but on a white background in a red diamond.

Carcinogen | Toxic | Corrosive | Flammable

Some chemicals cause **sensitisation**, which means they can produce an allergic reaction that will gradually worsen as exposure is repeated. There are two types:

- **Skin sensitisers** – can cause allergic dermatitis on contact with the skin (e.g. epoxy resin used in adhesives and paints).
- **Respiratory sensitisers** – can cause asthma and similar effects if inhaled (e.g. wood dusts and isocyanates).

Finally, there are two categories of substance that, although not often found in construction materials, can be of great concern when present:

- **Mutagens** – may cause genetic mutations that can be inherited.
- **Toxic to reproduction** – may cause sterility or affect an unborn child.

Acute and Chronic Health Effects

It is important to understand the difference between acute (short-term) and chronic (long-term) health effects from exposure to hazardous substances.

- **Acute effects** occur quickly after exposure (i.e. in seconds, minutes or hours), often from large amounts of a substance, e.g. inhaling high concentrations of chlorine gas causes immediate respiratory irritation. These effects are often reversible.
- **Chronic effects** take time to appear (i.e. months or even years) after exposure to smaller amounts of a substance over a longer period of time, e.g. working with lead can take months to accumulate high levels of lead in the blood. These effects are mostly irreversible.

In terms of prevention, chronic effects present the most difficult control problems. This is because:

- The effects occur over a long period, so the hazard is not recognised.
- The level of contamination required to produce chronic effects is often tolerated by people because they do not experience acute symptoms.
- Symptoms occur slowly, so they are not recognised until an advanced condition of harm has developed.
- When symptoms are recognised the harm may be too advanced for full recovery – sometimes no recovery is possible.
- Symptoms are often confused with 'normal' ill-health or with 'getting older'.
- Symptoms are not always easily identifiable in groups of people with the same exposure, owing to the effect of differing 'personal' metabolisms.

Many hazardous substances can have an acute **and** chronic effect. For example, inhaling solvent vapours can have an almost immediate narcotic effect (acute) and long-term repeated exposure to lower levels can cause liver damage over a number of years (chronic).

Revision Questions

1. State the physical forms of chemical agents which may exist in the workplace.
2. Identify the five main health hazard classifications of chemicals.
3. Define the characteristics of mist and fumes, and identify a potential source of each in construction activities.
4. Distinguish briefly between acute and chronic ill-health effects.

(Suggested Answers are at the end of Unit NCC1.)

Assessment of Health Risks

Key Information

- There are four main "routes" by which hazardous substances enter the body: inhalation, ingestion, absorption through the skin, injection through the skin.
- The body has defence mechanisms to keep hazardous substances out, and to protect from their harmful effects. The respiratory system is protected by the sneeze reflex, nasal cavity, ciliary escalator and macrophages.
- Knowledge about routes of entry is used during the assessment of health risks and to determine appropriate control measures.
- Information about the substances can be gathered from product labels, material safety data sheets, and exposure limit lists.
- Assessments sometimes require that basic surveys are carried out using equipment such as stain tube detectors, passive samplers, smoke tubes, dust monitoring equipment and dust lamps. There are some limitations in their use.

Routes of Entry

Hazardous substances enter the body through **absorption**. They can be absorbed through the skin, the lining of the lungs or the gastro-intestinal tract.

The way a substance gets to these absorption locations is along a **route of entry**. Absorption may take place anywhere along the route.

Some substances can cause physical harm from contact, e.g. battery acid burning the skin from spillages. Others, such as epoxy resin, can sensitise from touching the skin.

Topic Focus

There are four main **routes of entry** for hazardous substances into the body:

- **Inhalation** – the substance is breathed in through the nose or mouth and travels along the respiratory passages to the lungs. The lung is the most vulnerable part of the body, as it can readily absorb gases, fumes, soluble dusts, mists and vapours. This is the main means of entry of biological agents.

  There are two types of dust:
  - Inhalable – particles of all sizes that can be inhaled into the nose and mouth and upper reaches of the respiratory tract.
  - Respirable – particles smaller than 7 microns (7/1,000 mm) that can travel deep into the lungs.
- **Ingestion** – the substance is taken in through the mouth and swallowed, travelling the whole length of the gastro-intestinal tract through the stomach and the intestines. This may occur:
  - As a result of swallowing the agent directly.
  - From eating or drinking contaminated foods.
  - From eating with contaminated fingers.

  All forms of chemicals may be ingested, and some biological agents may also enter the body by this route.

Topic Focus

- **Absorption** through the skin – the substance passes through the skin from direct contact with the skin from contact with contaminated surfaces or clothing. It is mainly liquid chemicals which enter the body in this way, although other forms of chemical may either sufficiently damage the skin to gain entry or find their way through the eyes.
- **Injection** through the skin – the substance enters directly into the body by high pressure equipment or contaminated sharp objects piercing the skin. Chemical liquids, and sometimes gases and vapours, may enter the body in this way. Biological agents are often injected – either on needles, etc. or by biting from an insect or infected animal.

Although not a main route of entry, **aspiration** can also occur – where a substance already swallowed can be inhaled into the lungs – usually if a person is unconscious.

Defence Mechanisms

The body's response against the invasion of substances likely to cause damage can be divided into **superficial** and **cellular** defence mechanisms.

Superficial

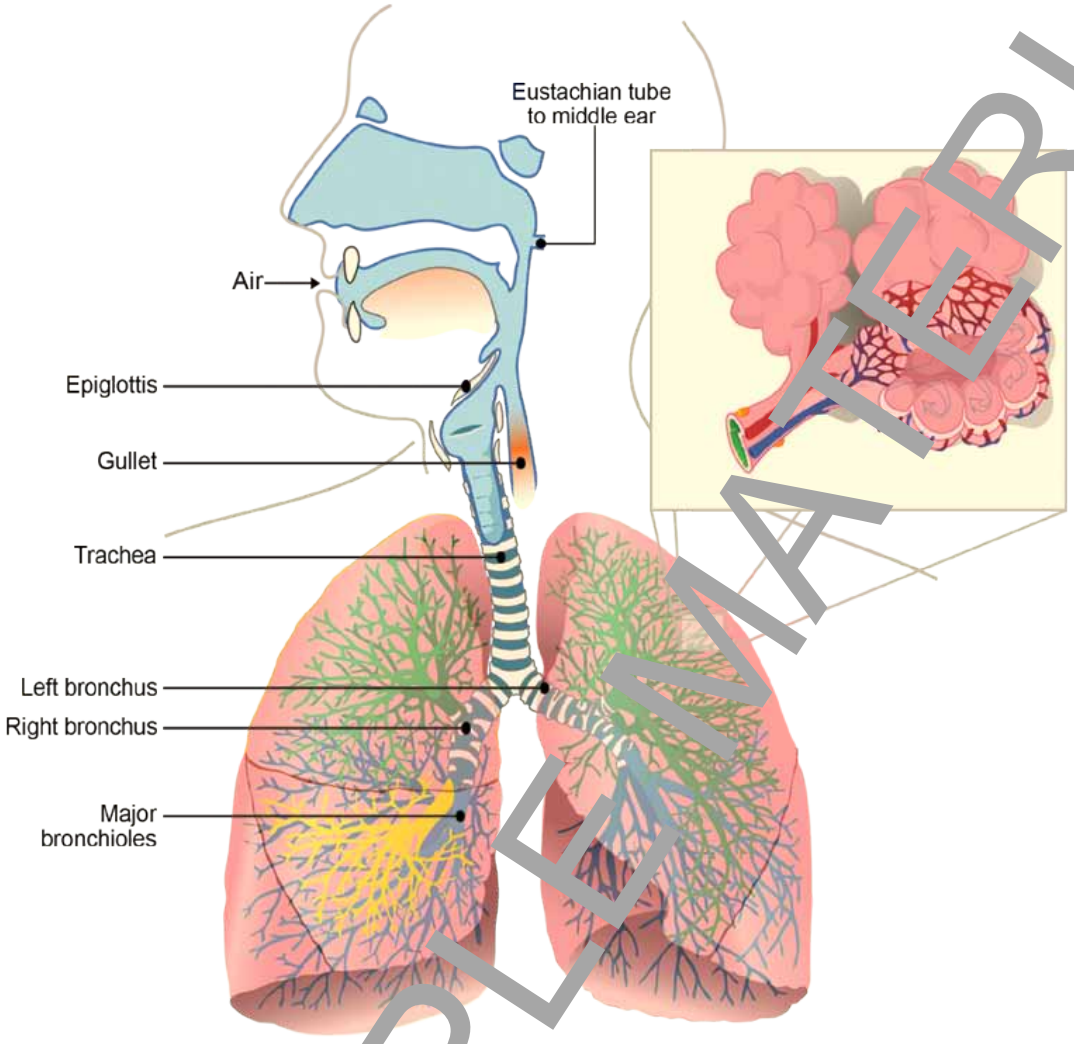
The **skin** provides a barrier against organisms and chemicals, but can only withstand limited physical damage. Some forms of dermatitis arise as a result of this damage, leading to thickening and inflammation of the skin which is both painful and unsightly.

The **respiratory tract** has a series of defences against inhaling contaminants:

- **The "sneeze" reflex** – immediate irritation causing sneezing to expel contaminants.
- **Nasal cavity filters** - substances and micro-organisms down to 10 microns are trapped by nasal hairs and mucus.
- **Ciliary escalator** – the bronchioles, bronchi and trachea are lined with small hairs (cilia), mucus lining these passages is gradually brought by these cilia out of the lungs. Particles above microns trapped in the mucus are cleaned from the lungs by this mechanism.

Hints and Tips

For most people memory is all about repetition, repetition, repetition - keep trying and it will sink in eventually!



The Respiratory System

Cellular

- **Macrophages** – scavenging white blood cells attack and destroy particles (less than 5 microns) that lodge in the alveoli (the gas-exchange region in the lungs) where there are no cilia to protect them.
- **Inflammatory response** – any particles that cannot be removed by the macrophages are likely to trigger an inflammatory response, causing the walls of the alveoli to thicken and become fibrous. This can be temporary or result in permanent scarring (as with silicosis).
- **Prevention of excessive blood loss** – through blood clotting and coagulation prevents excessive bleeding and slows or prevents the entry of contaminants into the blood.

Factors to be Considered when Assessing Health Risks

Where there is a potential for construction workers to be exposed to hazardous substances, it will be necessary to assess that potential to ensure that harm does not occur. This is a requirement of the **Control Of Substances Hazardous to Health Regulations 2002** (**COSHH**).

The risk assessment carried out to satisfy these regulations is often called a "**COSHH** Assessment". There are five steps to **COSHH** assessment:

1. Gather information about the substance used, the people who might be exposed and the work activities carried out.
2. Evaluate the health risks – are current controls adequate?
3. Identify any further controls and implement them.
4. Record the risk assessment and actions taken.
5. Review and revise.

When identifying the hazardous substances on the construction site remember that many are created by the work carried out, e.g. welding metal creates a metal fume; spraying paint creates an aerosol mist; these hazardous substances do not come pre-packaged and labelled, but are created by the construction work activities.

We will see later that you can collect information about hazardous substances by referring to various information sources. This information can be used to evaluate the health risks associated with the actual work practices.

Topic Focus

Factors to consider when carrying out an **assessment of health risks**:

- **Hazardous nature** of the substance – is it toxic, harmful, carcinogenic?
- **Physical form** of the substance – is it a solid, liquid, vapour or dust?
- The **quantity** of the hazardous substance present on site – including total amounts stored and the amounts actually in use or being created at any one time.
- Potential **ill-health effects** – will it cause minor ill-health or very serious disease? And will this result from short-term or long-term exposure?
- **Duration** – how much exposure and for how long? Will it be for just a few minutes, or most all day?
- **Routes of entry** – will it be inhaled, swallowed, absorbed?
- **Concentration** – will a substance be used neat or diluted? What is the concentration in the air?
- **The number of people** potentially exposed and any vulnerable groups of individuals – such as expectant mothers or the infirm.
- **The control measures** that are already in place – such as ventilation systems and PPE.

All these factors have to be taken into account when doing the **COSHH** assessment, and then the adequacy of any existing control measures can be decided and additional controls and precautions selected.

More...

http://www.hse.gov.uk/COSHH/index.htm

Sources of Information

To assist the assessment of health risks, further information will be required. This can be obtained from product labels, material safety data sheets and exposure limit documents.

Jargon Buster

Material Safety Data Sheets

Provide all necessary information about the substance for transport safety and to assist in carrying out the **COSHH** assessment.

Note: Often wrongly called "**COSHH** Sheets" they are, in fact NOTHING to do with the **COSHH Regulations** but rather relate to **CHIP** and **REACH**.

The **Chemicals (Hazard Information and Packaging for Supply) Regulations 2009** (**CHIP 4**) and the European **Registration, Evaluation, Authorisation and Restriction of Chemicals** (**REACH**) **Regulation** are the foundation of general chemicals legislation.

As we saw earlier with the change to GHS labels, **CHIP 4** is gradually to be superseded by the European **Classification, Labelling and Packaging** (**CLP**) **Regulation**, based on a Globally Harmonised System.

More...

REACH – the Registration, Evaluation, Authorisation and Restriction of Chemicals Regulation. Technical Update available for download from the Free Resources area of the RRC website:

http://www.rrc.co.uk

Product Labels

When supplying dangerous substances/preparations, a product label must give the following information:

- Name of the substance/preparation.
- Name(s) of the hazardous constituents.
- Indication(s) of danger and the corresponding symbols.
- Risk phrases.
- Safety phrases.
- Name, address and telephone number of the supplier.

Note that with GHS:

- Risk phrases will be superseded by hazard phrases.
- Safety phrases will be superseded by precautionary phrases.

A label showing the key information about the hazardous nature of the product

HSE Guidance Note EH40

This contains the lists of workplace exposure limits for use with the **COSHH Regulations**. The lists are reviewed annually and include information on materials under review for inclusion or for a change of category, plus lists of materials classified as "may cause cancer" or "may cause cancer by inhalation".

Manufacturers' Safety Data Sheets

Article 31 of **REACH** requires suppliers of dangerous substances and preparations to provide safety data sheets (this requirement was formerly within **CHIP**).

Safety data sheets are intended to provide users with sufficient information about the substance for them to take appropriate steps to ensure safe use, handling, transportation and disposal.

Topic Focus

Safety data sheets contain the following information:

- Identification of the substance or preparation, and supplier's name, address and emergency contact phone numbers.
- Hazard identification – a summary of the most important features, including likely adverse human health effects and symptoms.
- Composition and information on ingredients – chemical names, classification code letters and risk phrases.
- First-aid measures – separated for the various risks and specific, practical and easily understood.
- Fire-fighting measures – emphasising any special requirements.
- Accidental release measures – covering safety, environmental protection and clean-up.
- Handling and storage – recommendations for best practice, including any special storage conditions or incompatible materials.
- Exposure controls and personal protection – any specific recommendations, such as particular ventilation systems and PPE.
- Physical and chemical properties – physical, stability and solubility properties.
- Stability and reactivity – conditions and materials to avoid.
- Toxicological information – acute and chronic effects, routes of entry and symptoms.
- Ecological information – environmental effects of the chemical, which could include patterns of degradation and effects on aquatic, soil and terrestrial organisms, etc.
- Disposal considerations – advice on specific dangers and legislation.
- Transport information – special precautions.
- Regulatory information – e.g. labelling and any relevant national laws.
- Other information – e.g. list of relevant risk phrases, any restrictions on use (non-statutory supplier recommendations).

Safety data sheets must be supplied (paper or electronic) free of charge when the substance is first provided. They must be kept up-to-date and revised and reissued accordingly.

Limitations of Information in Assessing Risks to Health

The sources of information we have seen are important, but have limitations in assessing health risks:

- They contain general statements of the hazards, but do not take into account local conditions in which **you** will use the substances, which will affect the risk.
- The information can be very technical and difficult to understand by the non-specialist.
- Substances affect different people in different ways – this is not taken into account in the generalities used.
- Information is about a substance or preparation in isolation – no account is taken of the effects of mixed exposures.
- The information was good at the time it was written; it represents current scientific thinking, so there may be hazards present that are not currently understood.

Role and Limitations of Hazardous Substance Monitoring

Hazardous substance monitoring sets out to measure how much of a contaminant is in the air (inhalation is the only route of entry that we can positively measure), and we use this, together with time exposure, to assess the risks to health of substance exposure.

To carry out hazardous substance monitoring we use various types of sampling equipment to collect and measure how much contaminant is in the air.

Topic Focus

Sampling Techniques

The first task in our basic survey is to collect the sample of air so that it may be analysed. We need to consider (depending on the risk level of the contaminant being assessed):

- **Location of the sample** – it may be taken in the general working atmosphere, in the operator's breathing zone, or at a position close to the contaminant generation or use.
- **Method of analysis** – this may involve sampling and analysis in the same instrument, or taking the sample collected and analysing it using different equipment, perhaps in a laboratory away from the point of collection.
- **Duration of the sampling** – is the survey looking at short- or long-term exposures?

Hazardous substance monitoring surveys generally fall into three main categories:

- A **spot** or **grab** sample – a snapshot of airborne concentration at one moment in time – usually analysed on the spot.
- A better method of obtaining a time-weighted average is by **collecting a sample over a period** and then analysing it. This is the usual technique for personal monitoring.
- A **continuous monitored** sample (usually high risk areas) – where a sample is collected and continuously analysed over a period of time. Such systems may be linked to an alarm system if safe levels are exceeded.

There are two basic **methods of sampling**, based on the way in which the sample is collected:

- **Diffusion** or **passive sampling** – where the contaminant passes over the sampling system naturally, through an absorbent material which can be removed for later analysis.
- **Mechanical** or **active sampling** – where a pump provides air flow through the sampling device - used for both spot and continuous sampling.

Stain Tube Detectors

These are easy to use and useful for analysing gas and vapour contamination in air at one moment in time (spot sampling).

The principle of operation is simple – a known volume of air is drawn over a chemical reagent contained in a glass tube. The contaminant reacts with the reagent and a coloured stain is produced. The degree of staining can give a direct reading of concentration.

The instrument comprises a glass tube containing the chemical reagent fitted to a hand-operated bellows pump or piston-type pump. Many types of tube are available, with different chemicals that react to different gases and vapours. To operate:

- Select the appropriate tube.
- Snap off the end of the tube to open it.
- Place the open end on the pump and break off the other end.
- Squeeze the bellows or operate the pump for a specified amount (e.g. number of squeezes of the bellows).

This draws air through the detector tube, the chemical in the tube changes colour and the concentration of the contaminant can be read from a scale marked along the tube.

The following diagram illustrates the principle:

Stain tube before and after use. Note the closed and open ends of the tube. Arrow shows direction of air flow. n=10 indicates that 10 strokes on the hand bellows are required. These tubes are sensitive to carbon monoxide (CO). Final concentration is given as parts-per-million (ppm).

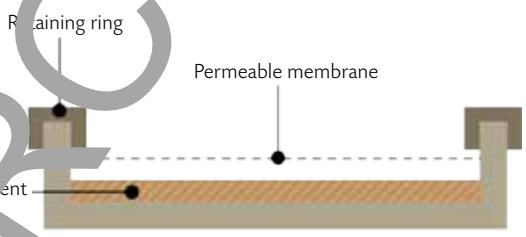
Limitations of stain tube detectors:

- Provide a spot-sample for one moment in time rather than an average reading.
- Can have an accuracy of +/-25%, which is not particularly accurate.
- Correct number of strokes must be used; losing count and giving too few/too many will give inaccurate results.
- Volume of air sampled may not be accurate due to incorrect assembly interfering with the air flow (through leaks, etc.) or incorrect operation.
- Can be cross-sensitive to substances other than the one being tested for.
- Designed to operate at about 20°C and one atmosphere pressure. Problems may be caused by variations in temperature and pressure away from these standard conditions.
- Tubes have a shelf storage life; out-of-date tubes may be inaccurate due to deterioration of the reagent.
- There may be variations in the precise reagent make-up between tubes.

Passive Samplers

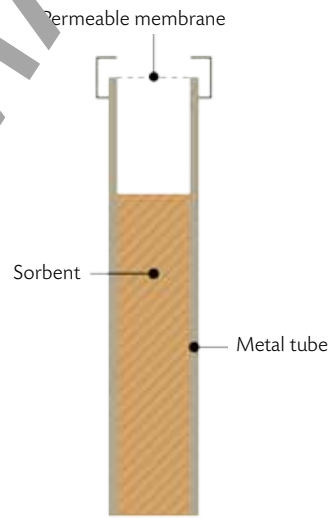
These use absorbent material to sample contaminants without using a pump to draw air through the collector. They give a measure of concentration over a period of time (long-term sampling) and can be used for gas or vapour. There are two main types of design:

- The **badge (or dish) sampler** has a flat, permeable membrane supported over a shallow layer of sorbent.



Badge sampler

- The **tube sampler** has a smaller permeable membrane supported over a deep metal tube filled with sorbent.



Tube sampler

They allow gas or vapour to diffuse to an absorbent surface. At the end of sampling, the sampler is sent for laboratory analysis, although some work on a colour-change principle similar to litmus paper. Working on a colour-change principle allows visual assessment against a standard chart.

Limitations of passive samplers:

- Do not provide any immediate indication of the contamination concentration – results have to be analysed.
- Only measure accumulated concentrations over the period for which they are in use – cannot be easily used to calculate time-weighted averages.
- Only sample contamination where they are located or, in the case of badges, where the wearer is – cannot be easily used to take spot samples in various parts of the workplace.
- Easy to take off, rendering them ineffective.