NEBOSH Certificate Courses - Sample Material

Unit NGC1

Unit NCC1

Unit FC1

Unit IGC2

Unit IOG1

Unit ICC1

nebosh
Accredited centre
335

RRC TRAINING

RRC Sample Material

Contents

NEBOSH Certificate Unit NGC1

Element 1: Foundations in Health and Safety

RRC TRAINING

Contents

Learning Outcomes

On completion of this element, you should be able to demonstrate understanding of the content through the application of knowledge to familiar and unfamiliar situations. In particular you should be able to:

- Outline the scope and nature of occupational health and safety.
- Explain the moral and financial reasons for promoting good standards of health and safety in the workplace.
- Explain the legal framework for the regulation of health and safety including sources and types of law.
- Explain the scope, duties and offences of employers, managers, employees and others under the **Health and Safety at Work, etc. Act 1974**.
- Explain the scope, duties and offences of employers, managers, employees and others under the **Management of Health and Safety at Work Regulations 1999**.
- Outline the legal and organisational health and safety roles and responsibilities of clients and their contractors.

Hints and Tips

Before you begin studying your course material, take a very quick look through the whole of NGC1. Don't read any of the information in detail - just aim to get an overview of the big picture and an idea of what you will be learning about later. Look out for the different Hints and Tips boxes too.

The Scope and Nature of Occupational Health and Safety

Key Information

- The study of health and safety involves the study of many different subjects including the sciences (chemistry, physics and biology), engineering, psychology, sociology and the law.
- There are many barriers to good standards of health and safety in a workplace: workplaces can be complex; there are often competing and conflicting demands placed upon people and organisations; and good health and safety practice often relies on the perfect behaviour of individuals, who sometimes fail to behave in this ideal way.
- Key definitions are:
  - **Health** - the absence of disease.
  - **Safety** - the absence of risk of serious personal injury.
  - **Welfare** - access to basic facilities.
  - **Environmental protection** - the prevention of damage to the air, land, water and living creatures in the wider environment.

The Multi-Disciplinary Nature of Health and Safety

Workplace health and safety practice brings together knowledge from many different disciplines. Some health and safety topics are simple to understand; others are technical and require specialist knowledge. Sometimes the practical solution to a health and safety problem is straightforward; at other times the solution is complicated and demanding and requires the correct application of technical knowledge and thinking.

In order to fully understand a health and safety issue you need to be familiar with:

- The technical background to the issue and have the relevant knowledge.
- The standards that may apply to the workplace and to the specific health and safety issue under consideration.
- The possible strengths and weaknesses of the various options that are available to solve the problem.

The study of health and safety therefore involves many different subjects including the sciences (chemistry, physics and biology), engineering, psychology, sociology and the law.

The Barriers to Good Standards of Health and Safety

There are many barriers to good standards of health and safety in a workplace:

- **Complexity** - workplaces can be complicated, involving the co-ordination of many people performing many different activities. Finding a solution to a specific health and safety problem or issue can be complex, requiring extensive background knowledge and an awareness of the possible consequences of the various courses of action that are available.
- **Conflicting demands** - there are often competing and conflicting demands placed upon people and organisations. A common conflict of interest is that between the need to supply a product or a service at an appropriate speed so as to make a profit, and the need to do so safely and without risk to people's health. Another conflict can be created by the need to comply with different types of standards at the same time, e.g. health and safety law as well as environmental protection law.
- **Behavioural issues** - good health and safety practice often relies on the perfect behaviour of individuals, and people sometimes do not behave in this ideal way. The solution to a health and safety problem usually requires a worker to carry out their job in a particular way. For example, a worker on a construction site should wear a hard hat to protect themselves from falling objects. But people are not robots; they do not behave as they are supposed to

all the time. Workers sometimes make mistakes (they do the wrong thing thinking that it is the right thing to do). Sometimes they deliberately do the wrong thing (knowing that it is wrong, but doing it anyway). The fact that health and safety standards are affected by worker behaviour can be a significant barrier to maintaining good standards in a workplace.

Behavioural issues - a worker ignores safety rules

Definitions

The topic of health and safety makes use of key words and phrases. Some important definitions are:

Health

The absence of disease or ill-health. For example, asbestos creates a health risk because if you inhale asbestos dust you may contract lung cancer (a disease) at some stage later in life (perhaps 20 or 30 years after you inhaled the dust). Health relates not only to physical ill-health but also to psychological ill-health (e.g. exposure to extreme stress can lead to nervous breakdown).

Safety

The absence of risk of serious personal injury. For example, walking under a load suspended from a crane during a lifting operation is not safe because, if the load falls, serious personal injury or death could result. Staying out of the danger area results in safety.

Welfare

Access to basic facilities such as toilet facilities, hand-wash stations, changing rooms, rest rooms and places where food can be prepared and eaten in relatively hygienic conditions, drinking water and basic first aid provision.

Welfare facilities - hand-wash stations

Environmental Protection

The prevention of damage to the air, land, water and living creatures in the wider environment. The word "environment" can be used simply to refer to the local area around a particular workplace or workstation, meaning the air, temperature, humidity, ventilation, light, etc. in that local area, but it can also be used in a wider context to refer to air, land, water and creatures. Environmental protection refers to the prevention of damage to this wider environment and is, of course, subject to legal standards.

Possible source of environmental damage

Revision Questions

1. Why may health and safety not be seen as a priority by the management of an organisation?
2. Define:

   (a) Health.

   (b) Safety.

   (c) Welfare.

   (d) Environmental protection.

(Suggested Answers are at the end of Unit NGC1.)

The Moral and Financial Reasons for Health and Safety

Key Information

- The three main reasons why an organisation has to manage health and safety are: moral, economic and legal. In this section two of these reasons are explored.
- The moral reason relates to the moral duty that one person has to another. Many people are killed, injured or made sick by their work. This is morally unacceptable and society expects good standards of health and safety.
- The financial reason relates to the fact that accidents and ill-health cost money. When an accident occurs there will be direct and indirect costs associated with that event. Some of these losses can be insured against; many of them will be uninsured.

Organisations and individuals have to manage health and safety standards within the workplace for various reasons. These reasons can usually be grouped under three main headings: moral, financial and legal. In this section the first two reasons will be explored.

The Size of the Problem

The following statistics are compiled by the Health and Safety Executive (HSE). These figures represent averages over recent years. Up-to-date annual figures can be obtained from the Statistics section of the HSE website. (You do not need to remember the actual figures; we give them to highlight the scale of the problem.)

Every year in the UK:

- **Over 220** workers are killed at work.
- **Over 29,000** workers suffer a major injury.
- **Over 110,000** workers suffer an over-3-day injury.
- Over **30 million working days are lost**:
  - 80% as a result of work-related ill-health.
  - 20% as a result of workplace injury.
- **2 million** people suffer from an illness they believe was caused or made worse by their current or past work.
- **Over 2,000** people die of mesothelioma, and thousands more from other occupational cancers and lung diseases.

These figures relate to the number of accidents and cases of disease which are reported and recorded. Inevitably there will be under-reporting and under-recording, so the real figures are almost certainly higher (e.g. the Labour Force Survey estimates over 300,000 reportable injuries occur each year).

Example of a workplace injury

These statistics indicate that a huge amount of pain and suffering is experienced by people who simply go to work to earn a living. The numbers indicate the scale of the problem. What the numbers don't do is tell the individual stories. When health and safety is not managed properly people get killed and injured in gruesome ways or suffer terrible diseases that have a massive impact not only on them, but also their dependants, families, friends and colleagues. This suffering is morally unacceptable.

Employers (through management) provide the premises and equipment and put in place the working practices which employees use to produce the goods and services with which employers earn profits. To that extent employers can be said to gain from the conditions at the workplace. In return, they provide an income for employees, but also have a moral responsibility to provide safe and healthy working conditions.

Societal Expectation

Standards of health and safety improve over time. Court cases indicate how a simple requirement such as "safe place of work" has changed over the years. What was considered a safe workplace in 1960 is very different to that which is expected 50 years on. Societal expectations change as society changes, for example:

- Well designed and reliable equipment, a comfortable workplace, organised systems of work and a high level of training are standards that people take for granted now because they are so common.
- Widespread access to knowledge now ensures that anyone interested in legal standards or best practice can find the relevant information.
- Media coverage now ensures that when poor standards of health and safety are revealed, this is broadcast to society quickly and by many different methods.

Though individuals often express an ambivalent attitude to health and safety, when a serious injury or disease is caused by work the overall response from society is not ambivalent, but one of condemnation.

The Business Case for Health and Safety

The business case for health and safety is simply that accidents and ill-health cost an employer money. When an accident occurs there will be direct and indirect costs associated with that event. Some of these losses can be insured against, but many cannot. The financial impact of accidents and ill-health can have significant effects on the profitability of an organisation and in some cases can lead to bankruptcy.

When an accident occurs there are two types of losses that the organisation may face:

- **Direct costs** - the measurable costs arising directly from the accident.
- **Indirect costs** - those which arise indirectly as a consequence of the event. Indirect costs are often difficult to quantify precisely and may be hard to identify. In certain circumstances they may be extremely high.

Hints and Tips

Read the course materials with a pen and paper to hand. Take lots of notes and be sure to jot down anything you want to ask your tutor about.

Topic Focus

Examples of **direct** costs:

- First aid treatment.
- Employee sick pay.
- Repairs to, or replacement of, damaged equipment and buildings.
- Lost or damaged product.
- Lost production time whilst dealing with the injury.
- Overtime to make up for lost time.
- Costs associated with the rehabilitation of the injured employee and their return to work.
- Fines in the criminal courts.
- Compensation payable to the victim, which is likely to be met by insurance cover and will therefore result in an increase in insurance premiums.

Examples of **indirect** costs:

- Loss of staff from productive duties in order to investigate the incident, prepare reports, undertake hospital visits, deal with relatives, attend court proceedings.
- Loss of staff morale (which impacts on productivity and efficiency).
- Cost of remedial action following an investigation, e.g. change of process or materials and/or the introduction of further control measures.
- Compliance with any enforcement notice served.
- Cost of recruiting and training temporary or replacement labour.
- General difficulties in recruiting and retaining staff as an indirect result of the accident.
- Loss of goodwill of customers following delays in production and fulfilling orders.
- Activation of penalty clauses for failing to meet delivery dates.
- Damage to public image and business reputation.
- Damage to industrial relations, perhaps leading to industrial action (e.g. strikes).

From the examples given you can see that though more difficult to identify, the indirect costs associated with a workplace accident can be very large indeed.

Insured and Uninsured Costs

It is usually possible to take out insurance to cover some of the losses that might foreseeably occur to an organisation. It is compulsory to take out employers' liability insurance (under the **Employers' Liability (Compulsory Insurance) Regulations 1998**, as amended) so that if an employee is killed or injured at work there is insurance in place to pay them (or their dependants) compensation. The minimum amount of cover is currently £5 million. The current certificate must be 'displayed' for the benefit of employees (though this can be made available in electronic form) and produced if required by an inspector.

Similarly, it is usual for an employer to insure their premises and stock against fire. However, it is not possible to insure against all losses. Some losses are uninsurable by their very nature. For example, you cannot take out an insurance policy to pay money should you be prosecuted and fined in the criminal law courts. Such insurance would, of course, negate the punitive and deterrent effects of the criminal legal system. Other losses are not insured because the loss is too difficult to quantify or because the insurance would be too expensive to consider. For example, organisations cannot insure themselves against loss of revenue if their business reputation is damaged through a major workplace accident. There is no law that prevents this type of insurance, it is simply impossible to obtain.

Many of the direct and indirect costs associated with workplace accidents are uninsured for these reasons. It has been estimated that uninsured losses are between eight and 36 times greater than insured losses. Examples of possible uninsured losses include:

- Loss of raw materials due to accidents.
- Sick pay for injured workers.
- Overtime to make up for lost production.
- Repair to damaged equipment.

It is worth remembering that most insurance policies come with an excess and with a limit. The excess is the amount of money that will be payable by the organisation before any payment is forthcoming from the insurer (for example, the first £5,000 of any claim). The limit is the cap above which the insurer will not pay (for example, if you have £2 million fire insurance but it costs £3 million to rebuild your premises, then the insurer will only pay the first £2 million, the remaining sum is uninsured).

More...

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

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

Revision Questions

3. In three words sum up the reasons why an organisation should manage health and safety.
4. Give examples of how societal expectations can result in higher standards of health and safety
5. Give three direct costs and three indirect costs that might arise from a workplace accident.

(Suggested Answers are at the end of Unit NGC1.)

The Legal Framework for Regulating Health and Safety

Key Information

- Two types of law create a framework for the regulation of health and safety: criminal law and civil law.
- Criminal law is concerned with the punishment of companies or individuals who have broken statute health and safety law.
- Civil law is concerned with the compensation of people who have been injured in work-related accidents through no fault of their own.
- Two sources of law are used in the criminal and civil systems: statute law and common law.
- Statute law is made by parliament in the form of Acts and Regulations.
- Common law is made by judges through the precedents that they set by their decision making.
- The law courts used for criminal and civil cases are different and there is a clear hierarchy to the court system, with the Supreme Court sitting as the highest court in the land.
- The enforcement of statute health and safety law is carried out by several authorities such as the Health and Safety Executive (HSE).
- HSE inspectors have many powers under the **Health and Safety at Work, etc. Act 1974** (**HSWA**) to investigate and examine workplaces. They can also issue Enforcement Notices or prosecute in the criminal courts.
- The two types of Enforcement Notice are the Improvement Notice and the Prohibition Notice. Certain conditions have to be met before an inspector can issue either notice. The employer can appeal against these notices to an Employment Tribunal.
- Successful prosecution of a company or an individual under **HSWA** can lead to fines up to £20,000 and/or imprisonment up to 12 months at Magistrates Court, or unlimited fines and/or 2 years imprisonment at Crown Court.
- The civil legal system is concerned with claims for compensation using two routes; Negligence and Breach of Statutory Duty.
- For negligence to be proved three tests have to be met: a duty of care had to be owed by the defendant to the claimant; that duty must have been breached; a loss must have occurred as a direct result.
- An important principle in the civil legal system is vicarious liability which means that the employer can be held liable for the negligent acts of his employees.
- There are various defences against a claim of negligence, one of which is the principle of contributory negligence; that the claimant was partly to blame for their own injury and so should not be awarded full compensation.
- There are five proofs of breach of statutory duty and various defences are available.

Criminal and Civil Law

Two main types of law create a framework for the regulation of health and safety; criminal and civil law. Before examining each type in detail it is worth outlining some general principles and characteristics of this framework.

Topic Focus

The table below summarises the two types of law and shows some of the significant differences between the two.

Criminal law	Civil law
Action is brought by the state.	Action is brought by the individual.
The intention is punishment.	The intention is compensation.
Legal proceedings are normally started within 6 months of the offence coming to light.	Legal proceedings have to start within 3 years of the date of injury.
Insurance is not available to pay the fine.	Insurance is available to pay the compensation.
Statute law is used as the source of law.	Common and statute law is used as the source of law.
The burden of proof normally required is "guilt beyond reasonable doubt".	The burden of proof required is "on balance of probabilities".

A simple workplace accident can trigger both types of legal action. For example, imagine a scenario where an employee is run over by a forklift truck and suffers multiple broken bones.

The **criminal law** implications might be:

- This accident might be investigated by a Health and Safety Executive (HSE) inspector. The HSE are an enforcing authority acting on behalf of the state.
- They might decide to prosecute the company involved, for a breach of **HSWA** (i.e. for a breach of statute law).
- Any prosecution would be done on behalf of the state and the court papers would reflect this (the case would be recorded as Regina (the Crown) - versus - the organisation).
- If the organisation were found guilty of an offence they would be fined. The fine cannot be reclaimed from an insurance company and it is not an allowable business expense (i.e. it cannot be written off against tax). This is the punishment for breaking the law.

The intention of the criminal legal system is to punish those who break the law. (It is important that justice is seen to be done; the punishment has a deterrent effect on the organisation involved and on other organisations who might also be breaking the law.) However, it does not necessarily help the injured employee. If the injured employee in this scenario wants financial compensation for an injury that was not their fault, then they will have to turn to the civil legal system.

The **civil law** implications might be:

- The injured employee sues their employer for compensation.
- To do this they instruct a solicitor to act on their behalf. The letter of claim to the employer has to be sent within **three years** of the date of the accident.
- If the case goes to court then the court papers will reflect that the employee is suing their employer; their name - versus - their employers name will appear in the case records.
- In the court the employee's legal team can use **common law** and perhaps **statute law** to support their case.
- The employee will need to show that their employer was liable for their accident **on balance of probabilities**.
- If the employee wins then the court decides how much **compensation** should be paid. This compensation is paid from the employer's **insurance** policy.

There are, of course, many complications and technicalities that are not reflected in the scenario above. For example, most claims for compensation are settled out of court between the injured party (the claimant) and the insurance company of the organisation, so no court case actually happens. Many occupational diseases take more than three years for symptoms to appear and therefore the three year rule cannot be applied from the date of exposure to the harm, it has to be applied to the date when the person first become aware that they have the disease (i.e. three years from diagnosis to start the claim process). Sometimes individuals are prosecuted in the criminal courts for offences under **HSWA** and where this occurs there is the possibility of a fine and/or imprisonment being handed down as punishment.

However, the above scenario and general characteristics are useful as a general frame on which more detailed information will be hung later in this element.

Sources of Law

There are two sources of law that are relevant to the criminal and civil legal systems outlined above; statute law and common law. Put simply, statute law is made by parliament and exists in the form of Acts, Regulations and Orders. Common law is made by judges through the decisions that they make and the precedents that they set. It is, in effect, the law of the land as established by custom and practice.

Statute Law

- **Acts**

  The most important piece of statute law relating the health and safety in workplace is, of course, **HSWA**. This is the primary piece of statute law for the course. Other Acts also impact on health and safety (such as the **Corporate Manslaughter and Corporate Homicide Act 2007**).

- **Regulations**

  HSWA is an enabling act, meaning that it allows for the creation of health and safety regulations such as The **Management of Health and Safety at Work Regulations 1999 (MHSWR)**. These regulations are referred to as delegated (or secondary) legislation. There are dozens of sets of regulations made under **HSWA**.

- **Approved Codes of Practice**

  Approved codes of practice (ACoPs) often accompany regulations (e.g. there is an ACoP for **MHSWR**). ACoPs explain how to achieve the legal standard outlined in the regulation that they accompany and give a clear indication of what is expected. ACoPs do not have the full legal status of Acts or Regulations. Instead they have special or semi-legal status. Failure to comply with an ACoP can be used as evidence of failure to achieve legal standards. If an ACoP has not been complied with then it must be shown that alternative methods were used that achieve at least the same standard as the ACoP.

- **Guidance**

  Official guidance also often accompanies regulations (e.g. there is guidance on the **Manual Handling Operations Regulations 1992**). Guidance has no legal status but is useful in interpreting legal standards. Guidance often sets out best practice.

- **Relevance of Statute Law**

  Both **HSWA** and **MHSWR** are frequently used in bringing prosecutions in the criminal courts.

  The **HSWA** is never used in bringing a claim for compensation in the civil court. The reason for this is that one section of **HSWA** specifically prevents its use in the civil courts (i.e. it is "statute barred").

  The **MHSWR** are sometimes used in bringing a claim for compensation in the civil courts, because they do not contain a similar exclusion.

Common Law

Common law is not recorded in the form of Acts and Regulations. Instead it is made up of decided cases. A court case requires a judge (or several judges) to make a decision and perhaps state the reasons for their decision. These reasons may then establish a precedent that will influence the decision making of judges in the future. Common law is therefore recorded in the form of past court cases and the reasoning stated in those cases. Common law relies heavily on the principle of judicial precedence; the idea that judges in courts have to take note of and follow the precedents set in courts higher in the court hierarchy. Therefore the Supreme Court (was House of Lords) sets binding precedents for all other courts.

- **The Employer's Common Law Duties**

  The common law duties of an employer were identified in general terms in the decided case of ***Wilsons and Clyde Coal Co. Ltd v. English (1938)***. The judgement established the common law duty of all employers to provide:

  - A safe place of work with safe access to and from it.
  - Safe plant and equipment.
  - A safe system for doing the work.
  - Safe and competent workers.
  - Appropriate supervision, information, instruction and training.

  These common law duties were used as a basis for some of the statutory duties in **HSWA**.

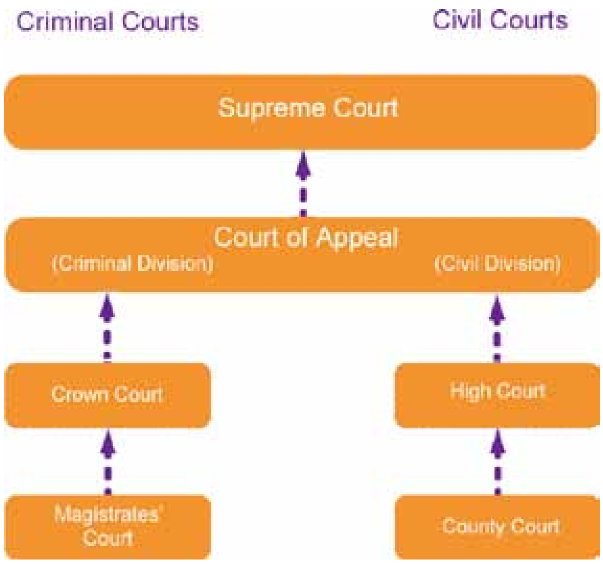
- **Relevance of Common Law**

  Common law is frequently used in the civil courts when bringing a claim for compensation. However, it is not used when bringing prosecutions against employers for health and safety failings. In very rare cases a prosecution may be brought against an individual on the basis of manslaughter by gross negligence. This is a common law offence.

Court Structure

England, Wales and Northern Ireland

The structure of the law courts reflects the fact that there are two separate types of law (criminal and civil). The general structure of the courts is outlined in the following diagram:



Criminal and Civil Courts in England, Wales and Northern Ireland

All criminal cases go to the Magistrates Court in the first instance. More serious cases will then be sent up (indicted) to Crown Court. An appeal might then be made to the Court of Appeal (Criminal Division) (or the High Court in some instances). Final appeal might then be allowed to the Supreme Court.

Civil cases will either go to the County Court or High Court depending on the amount of compensation being claimed. Typically claims of less than £50,000 are settled in the County Court and more than £50,000 in the High Court. Any first appeal will go to the Court of Appeal (Civil Division)). Final appeal might then be allowed to the Supreme Court.

Again there are various technicalities and details, some of which will be discussed later in this element, but this general outline is useful as a starting point.

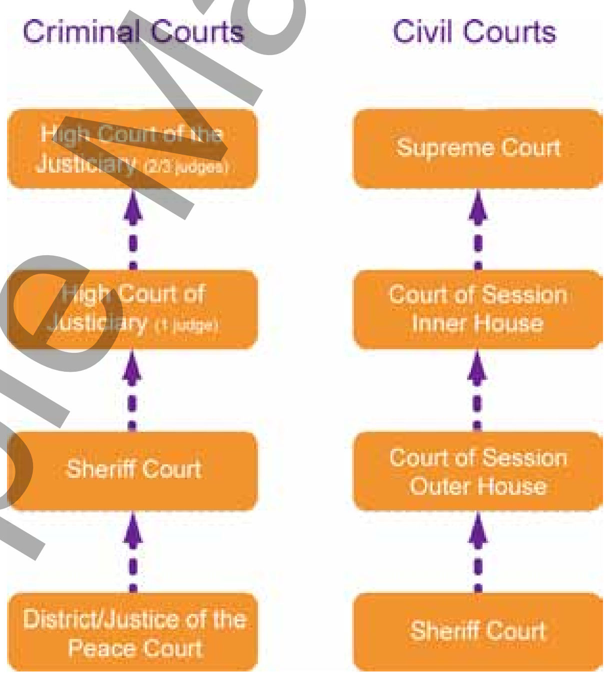
Apart from the obvious separation of the criminal and civil systems, two points should be noted:

- There is a clear hierarchy, with lower courts and higher courts. The higher a court is in the structure, the more influence the court has over courts lower down. For example, judges in the Court of Appeal get to set precedents that other judges in lower courts have to follow.
- The Supreme Court is the court of final appeal in almost all instances and can set precedents for all other courts. It straddles both systems.

Hints and Tips

The court structure in Scotland is different to that found in other parts of the UK. Knowledge of both systems is not required, but knowledge of one system is. You are free to choose whichever system seems most appropriate to your needs.

Scotland



Criminal and Civil Courts in Scotland

The diagram above shows a simplified structure for the Scottish courts. Criminal cases go to the Justice of the Peace, Sheriff or High Court depending on the severity of the offence. Appeals are then made to the next court up in the structure (except in the High Court where appeals are heard internally). Similarly civil claims go to the Sheriff Court or Court of Session (depending on value) and appeals are heard by the next court up in the structure. Again, there is clear separation between civil and criminal courts and a clear hierarchy.

The Influence of the European Union

The European Union was created by the Treaty of Rome in 1957. One of the intentions of its creation was the easy exchange of goods and services between member states. To that end, there has been a significant drive to harmonise health and safety standards across Europe.

This harmonisation is achieved by the introduction of:

- **European Regulations** – statutory instruments that impose legal standards onto member states and take precedence over internal law.
- **European Directives** – statutory instruments that require member states to achieve a certain legal standard through their own internal legislation within a timescale.

A lot of health and safety legislation introduced in the UK (since 1992) has been driven by European Directives. For example the **MHSWR**, were first introduced to comply with such a directive.

UK law is influenced by European Directives

Criminal Law

The Enforcing Authorities

There are several enforcing authorities who have a role in enforcing health and safety law in the UK. First amongst these is the Health and Safety Executive (HSE) and their equivalent body in Northern Ireland the Health and Safety Executive for Northern Ireland (HSENI).

The HSE enforce health and safety law in a wide range of workplaces. These include factories, mines, quarries, construction sites, nuclear installations, off-shore oil and gas facilities, chemical plants and agriculture. These might be described as the medium and high risk workplaces. The HSE do not, however, enforce in all workplaces and they do not generally enforce fire safety or environmental protection legislation.

The HSE have a number of roles:

- Enforcement of **HSWA** and associated law.
- Reviewing existing legislation and making recommendations for changes.
- Providing information and guidance.
- Conducting research.

The HSE website is an excellent source of information on legal standards and best practice (www.hse.gov.uk).

Local authorities enforce health and safety law in workplaces not covered by the HSE, such as hotels, restaurants, offices and depots. These might be described as lower risk workplaces. Enforcement is carried out by Environmental Health Officers (EHOs) who have the same powers under **HSWA** as HSE inspectors.

Fire and Rescue authorities are the main enforcing agents for general fire precautions under the **Regulatory Reform (Fire Safety) Order 2005**. They have a number of enforcement options available to them, including issuing an alterations notice, enforcement notice, prohibition notice and prosecution. Fire Safety Inspectors have powers similar to those of HSE inspectors.

The Environment Agency enforces environmental protection law in England and Wales. In Scotland the corresponding organisation is the Scottish Environment Protection Agency.

In some countries insurance companies fulfil a major role in enforcing safety. In the UK, their legal role is limited to inspecting certain items of equipment. However, the inspections and audits they undertake of their clients' premises supplement those of the authorities, and in some cases are the only inspections which occur on a regular basis. They can exert considerable influence in raising standards, as they can refuse to provide insurance cover unless their standards are met.

Powers of Inspectors under HSWA

Inspectors appointed under **HSWA** have wide ranging powers to enter and inspect premises to ensure that activities are being carried out in accordance with the law.

Health and safety inspector

Topic Focus

Under Section 20 of **HSWA** inspectors have the following powers:

- To enter premises, at any reasonable time.
- To take along a police officer if they believe they are going to be obstructed.
- To take along technical assistance or equipment if necessary.
- To carry out any necessary examinations and investigations.
- To direct that premises (in whole or in part) or items within the premises are left undisturbed.
- To take photographs, drawings and measurements.
- To take samples of articles or substances and of the atmosphere.
- To dismantle and/or test any item or substance which they think is dangerous.
- To take possession of articles and substances for examination or test, or as evidence in proceedings.
- To take statements from any person who might be able to help in their investigation. Interviewees must answer any questions and sign a statement of their answers (although these are not admissible as evidence in any subsequent proceedings against that person).
- To inspect and copy any document or record considered relevant.
- To receive access to reasonable facilities and assistance in conducting their investigation.
- Any other power necessary to fulfil the duty of their enforcement authority.

Section 25 of **HSWA** adds an additional power:

- To seize and render harmless (by destruction if necessary) any article or substance that gives rise to imminent danger of serious personal injury.

Whilst the general policy is to promote compliance through co-operation and discussion, inspectors do have the power to issue enforcement notices and, if necessary, to prosecute offenders.

Enforcement Notices

There are two types of enforcement notice – improvement notices (issued under section 21 of **HSWA**) and prohibition notices (issued under section 22).

Topic Focus

Improvement Notices

- An Improvement Notice is issued where the inspector thinks that health and safety law is being breached or a breach has occurred and is likely to be repeated.
- It will only be issued if the inspector does not think there is a risk of serious personal injury.
- The Improvement Notice will state that an improvement must be made to achieve minimum legal standards and will impose a timescale that the inspector thinks is appropriate.
- The timescale for an Improvement Notice cannot be less than 21 days.
- The inspector may state the specific action needed to achieve legal compliance and make reference any relevant ACoP or guidance.
- The Improvement Notice is served on the person in charge of the workplace or activity that is in breach; this is normally the employer.
- Any appeal against the notice must be made within 21 days.

So, for example, an inspector investigating a call centre were 30 staff work with display screen equipment (DSE) for 9 hour shifts would expect to see DSE workstation assessments being conducted as required by the **Health and Safety (Display Screen Equipment) Regulations 1992**. They would also expect to see free eye tests being offered to employees. If these assessments and eye tests were not being provided then the inspector would be entitled to issue an Improvement Notice, requiring the employer to carry out the assessments and offer the free eye tests within a specified timescale (e.g. 2 months), because:

- The relevant regulations are being breached.
- It is not a trivial matter in a call centre.
- No-one is at risk imminent serious personal injury.

Topic Focus

Prohibition Notices

- A Prohibition Notice is issued where the inspector thinks that there is a risk of serious personal injury.
- The Prohibition Notice will state that the activity must be stopped until such time as it has been remedied.
- No timescale is specified.
- The inspector does not need to see a breach of health and safety law.
- The Prohibition notice is served on the person in control of the activity; this is often the employer.
- Any appeal against the notice must be made within 21 days.

So, for example, an inspector investigating an engineering factory where a large guard covering a dangerous moving part of machinery is missing might issue a Prohibition Notice. Any person coming into contact with that moving part might be pulled into the machinery and suffer a very serious injury or even be killed. The machine must immediately be taken out of use and cannot be reused until it has been made safe (e.g. by fitting the relevant guards).

Example of guarded machinery

Appeals Against Enforcement Notices

Appeals against Notices are made to an **employment tribunal**. The appeal must be in writing and state the grounds for the appeal.

The main grounds for an appeal are:

- There has been a wrong legal interpretation by the inspector.
- The inspector has exceeded his powers.
- A breach of the law is admitted, but the suggested remedy or timescale is not practicable or reasonably practicable (we will discuss this further in the following section of this element).
- A breach of law is admitted, but it is insignificant.

For an Improvement Notice, bringing an appeal **suspends** the notice until the appeal is heard or withdrawn.

For a Prohibition Notice, the prohibition **remains in place** unless the tribunal directs otherwise.

The decision of the tribunal may be to:

- Cancel the notice.
- Affirm (uphold) the notice.
- Affirm and modify the notice (e.g. by extending the timescale).

Further appeals against the tribunal's decision will go to the Employment Appeals Tribunal which is linked into the Court of Appeal (Civil Division).

The emphasis is upon simplicity and speed. Often, in order to speed up the procedure, a tribunal will order a preliminary hearing to see if the matter can be resolved between the parties without a full tribunal taking place.

Failure to Comply

Failure to comply with an enforcement notice can result in a fine and/or a prison sentence. Maximum penalties are:

- Magistrates court: £20,000 maximum fine and/or 1 year imprisonment.
- Crown court: unlimited fine and/or 2 years imprisonment.

Formal Cautions

The "formal caution" procedure is used by some local authorities providing that the evidence available suggests that a conviction is more likely than an acquittal before a court, the offender admits the offence and agrees to be cautioned.

HSE enforcement officers tend to use alternative enforcement options available under the **HSWA**.

In Scotland, the Procurator Fiscal decides whether, in the particular case, a formal caution should be issued rather than taking legal proceedings.

Prosecution

Criminal prosecutions result in a trial heard in either the Magistrates' Court or the Crown Court (in England and Wales) or the District or Sheriff Court (in Scotland). The case is brought by the enforcement agency itself in England and Wales, although in Scotland the Procurator Fiscal brings the case on behalf of the inspectors.

The particular court in which a case is held depends upon the type of offence and dictates the penalties which may be imposed.

There are three types of offence:

- **Summary Offences**

  These are minor offences which can be decided in a Magistrates' Court (England and Wales) or the District Court or Summary Division of the Sheriff Court (in Scotland).

- **Indictable Offences**

  These are the more serious types of offence. A formal document (the indictment) is drawn up following committal proceedings held in the Magistrates' Court (Sheriff Court in Scotland).

  The trial of indictable offences takes place before a judge (and jury) in the Crown Court in England and Wales, or, in Scotland, the Solemn Division of the Sheriff Court or the High Court of Justiciary.

- **Triable Either Way**

  These are offences which may either be tried as summary offences in the Magistrates' Court or be heard by a judge and jury in the Crown Court. The particular approach may be determined either by the prosecution (when the gravity of the offence will be the main influence) or by the accused exercising his/her option to be tried by jury.

  Most health and safety offences fall into this category.

Penalties

The sentence imposed for a breach of health and safety law will depend on which court is involved:

- Magistrates court:
  - £20,000 maximum fine and/or
  - 1 year prison
- Crown court:
  - Unlimited fine and/or
  - 2 years prison

Similar penalties may be imposed by the equivalent courts in Scotland. These penalties are set out in by the **Health and Safety (Offences) Act 2008**.

Criminal courts can make a compensation award to a person who has been injured or has suffered loss as a result of a criminal offence. This is in addition to any punishment from the Court. Criminal courts do not usually do this in health and safety cases where an employee is able to gain compensation by way of a civil action.

Defences

Where a prosecution is being brought under **HSWA**, the accused can defend themselves by arguing that they have done everything that was practicable or reasonably practicable.

However, Section 40 of **HSWA** reverses the normal burden of proof and puts the onus on the accused to demonstrate their innocence. If they had done all that could reasonably have been done under the circumstances, then this would be deemed an adequate defence to make. This, for example, could be done by demonstrating that an ACoP had been complied with. The standard of proof here is that the defendant must demonstrate their innocence on "the balance of probabilities".

This is different from most criminal cases, where there is a presumption of innocence and the prosecution must prove guilt "beyond reasonable doubt".

Manslaughter

In very rare cases organisations and/or individuals are charged with manslaughter (or homicide in Scotland) associated with a health and safety failure that has caused death. This is a very serious criminal offence:

Individuals – can be charged with *gross negligence manslaughter* (or *culpable homicide* in Scotland); where their conduct fell well below the standards of a reasonable man. This carries a maximum sentence of life imprisonment.

Organisations – can be charged with *corporate manslaughter* (*corporate homicide* in Scotland). The sentence is an unlimited fine and the organisation may be ordered to publicise its offence.

The **Corporate Manslaughter and Corporate Homicide Act 2007** has simplified the law on corporate manslaughter.

Under the Act an organisation will be guilty of the offence if the way that the organisation managed or organised its activities:

- Caused a person's death *and*
- Amounts to a gross breach of their duty of care to the deceased *and*
- If the way in which the organisation is managed or organised by its senior management is a substantial element in the gross breach.

Note that in some cases individuals *and* organisations have been charged with offences under **HSWA** *and* with manslaughter and corporate manslaughter offences:

- The **individual** might be charged with a Section 7 offence and gross negligence manslaughter.
- The **organisation** might be charged with a Section 2 offence and corporate manslaughter.

Civil Law

Tort of Negligence

A tort is a civil wrong. The remedy for a tort is action through the civil courts. In Scotland the word delict is used instead.

Torts include civil wrongs such as defamation and trespass, but the one of particular interest in the context of health and safety is Negligence.

Negligence can be simply defined as a failure to take reasonable care when a duty to do so existed.

If a person is injured or suffers some other form of loss as a result of someone else's negligence then they can use the civil legal system to claim compensation using the Tort of Negligence.

To demonstrate negligence the claimant must show that:

- A duty of care was owed to them by the defendant (the person or organisation that they are suing).
- This duty of care was breached.
- They suffered an injury or loss as a direct result of the breach of duty of care.

The claimant must prove their case on a balance of probabilities.

- **Duty of Care**

  The concept of a "duty of care" stems from common law and the case of ***Donoghue v. Stevenson (1932)***. This case involved a woman consuming a soft drink in which was found the remains of a decomposed snail. She was subsequently ill and sued the manufacturer. In the judgment, it was held that reasonable care must be taken to avoid acts or omissions which, with reasonable foresight, you would know would be likely to injure your neighbour. This is known as the **neighbour principle**.

  In other words, you owe a duty of care to your neighbours, i.e. to the people who it is reasonably foreseeable that your acts or omissions might harm.

- **Breach of Duty**

  This has nothing to do with a breach of statute law. Instead the question is whether the defendant behaved in a **reasonable** manner. The breach of duty might be by **act** or by **omission**. Did the defendant act in a way that a reasonable person might be expected to act in the circumstances? Or did they omit to do something that a reasonable and prudent person might be expected to do in the circumstances?

- **Injury as a Direct Result**

  The injury or loss must have arisen directly from the breach of duty of care and the claimant will have to demonstrate this. There must be a straightforward causal link from one to the other. For example, failure to support the sides of the excavation (breach) lead to the collapse of the excavation which in turn lead to the crush injuries to the worker in the excavation.

The three proofs for negligence give rise to the **defences** that might be used by the defendant:

- **No duty of care owed** – the defend at did not owe a duty of care to the claimant so did not have to have them in mind as they went about their activities.
- **Duty of care not breached** – the defendant did everything that a reasonable and prudent person might have done in the circumstances.
- **No injury or loss as a direct result of the breach** – the nature of the injury or loss cannot be substantiated, or it has occurred but cannot be linked directly to the breach of duty by the defendant.

There are other defences available such as:

- *Volenti non fit injuria* – the idea that the claimant was a willing volunteer and accepted the risk of personal injury when taking part in the activity. This defence cannot be used by an employer to defend a claim from his employees.
- Contributory negligence – see below.
- The facts of the case are disputed.

Contributory Negligence

Contributory negligence is a partial defence against a claim of negligence where **a part of the blame for the injury is attributed to someone else** other than the defendant. In many cases it is used as a way of passing some of the blame for the injury to the claimant. Other parties might also be held responsible.

For example, if an employee fails to comply with their training, fails to use the PPE that has been provided and fails to heed warning signs, they might receive an injury. If that employee can then demonstrate that there was a complete failure to provide adequate supervision in the workplace (which would have ensured that they used the PPE) then they may be able to claim compensation for their injury.

The employer might admit partial liability for the injury because they failed to provide adequate supervision. But the employer might also claim contributory negligence because the employee had been trained, provided with PPE and warning signs were in place. If the judge accepts this argument they will award damages on a pro-rata basis depending on where they see the blame being apportioned.

Vicarious Liability

Vicarious liability is the simple idea that **an employer can be held liable for the negligent acts (or omissions) of his employees**. So if an employee is negligent and injures another person then that injured person can claim compensation through the civil legal system from the employer (rather than having to sue the individual employee who actually caused their injury).

So, for example, when an untrained, unauthorised driver runs over a member of the public whilst trying to move a loaded pallet with a forklift truck, the injured member of the public can sue the employer for their injury.

The main restriction on vicarious liability is that the employee has to be acting in the course of employment when they commit their negligent act. If they were not working when they caused the injury, then they can be held personally liable and their employer can escape liability.

Tort of Breach of Statutory Duty

This is an alternative route to claiming compensation for a work-related injury. Instead of using common law to demonstrate that a duty of care existed and was breached, statute law is used as the basis of the claim.

To demonstrate Tort of Breach of Statutory Duty the claimant must show that:

- The statutory duty was placed on the defendant.
- The statutory duty was owed to that claimant.
- The defendant was in breach of the statutory duty.
- The breach of statutory duty caused the injury.
- The injury was of a type that the statute existed to prevent.

There are a number of defences available against Tort of Breach of Statutory Duty:

- The breach is statute barred – i.e. the relevant statute cannot be used in bringing a civil action because it is specifically excluded from use in the civil courts (e.g. **HSWA**).
- No statutory duty was owed to that claimant – the law often only specifically protects employees. In this case, if the claimant is not an employee they are not owed the duty.
- No breach of statutory duty – the defendant complied with the legal requirements.
- There was no causal link between the breach of statutory duty and the injury – for example failure to fit handrails to stairs (a breach) will not protect someone carrying a load in both hands in the event of a fall, because they could not have used the handrail anyway.
- The injury was not of a type that the statute existed to prevent.

Double Barrelled Action

When a claimant is seeking compensation for a work-related injury they may be able to use both torts at the same time:

- Tort of Negligence, and
- Tort of Breach of Statutory Duty.

Such an action is often referred to as a double barrelled action.

Note, however, that success in both cases does not result in twice the compensation.

Compensation

The compensation awarded to a successful claimant is intended to return the claimant to the position that they were in before the injury occurred. Whilst the court cannot repair the damage of an injury, they can award money to compensate for that injury. The compensation awarded is split into two categories:

- **General damages** – for pain and suffering, loss of amenity, loss of future earnings, etc. These amounts are for the court to quantify.
- **Special damages** – for loss of earning up to the trial date, travel expense to hospital, etc. These amounts have to be quantified and proven by the claimant.

So the amount of compensation awarded is directly determined by how much pain and suffering was caused by the event and by any treatment or rehabilitation that followed, how much loss of amenity (enjoyment of hobbies, pastimes, etc.) has been caused and how the injury has impacted on the persons financial situation and their ability to earn a living.

Employment Tribunals

Employment tribunals are not involved in determining compensation for work-related injures.

They are, however, responsible for settling disputes that arise out of employment law, such as cases on:

- Unfair and constructive dismissal.
- Sex, Race and Age discrimination.

In the context of health and safety law Employment Tribunals are important for two reasons:

- They hear appeals against enforcement notices.
- They hear appeals from Safety Representatives whose rights have been withheld.

Employment tribunals provide a cheaper, less formal way to resolve disputes without recourse to the courts. There is a link from tribunals into the civil legal system.

Revision Questions

6. What is the legal status of:

   (a) Regulations?

   (b) Approved Codes of Practice?

   (c) HSE Guidance Notes?

7. What is the difference between the civil and criminal law in respect of:

   (a) The remedy sought?

   (b) The burden of proof?

   (c) Who starts the legal action?

8. Explain the principle of judicial precedence.

9. What is delegated legislation?

10. What are the common law duties of employers?

11. What is the difference between an improvement notice and a prohibition notice?

12. Does an appeal against an enforcement notice suspend the notice?

13. What role do employment tribunals have in health and safety?

14. What are the tests of negligence?

15. What is the relationship of the health and safety regulations to **HSWA**?

16. What are the two main enforcement agencies for health and safety under **HSWA** in the UK?

17. Identify four powers of inspectors under Section 20 of **HSWA**.

(Suggested Answers are at the end of Unit NGC1.)

The Health and Safety at Work, Etc. Act 1974

Key Information

- The **Health and Safety at Work, etc. Act 1974** is the principal piece of statute law regulating health and safety in workplaces. The Act creates duty holders and identifies who they owe a duty towards.
- The employer owes a duty to his employees to ensure, so far as is reasonably practicable, their health safety and welfare at work.
- So far as is reasonable practicable is a key phrase meaning that a balance must be struck between the level of risk and the cost, measured in time, money and effort, of reducing that risk.
- An employer also owes a duty to ensure the health and safety of non-employees.
- People who control premises used as workplaces (such as office landlords) have a duty to the people using those premises.
- Designers and manufacturers of articles or substances used at work have a duty to the end users.
- Employees have a duty to themselves and others and must co-operate with their employer.
- The Act also prohibits anyone from misusing safety equipment and prohibits employers from charging employees.
- Directors, senior managers and external advisers can be charged with offences committed by an organisation.

Scope

The **Health and Safety at Work, etc. Act 1974** (**HSWA**) covers all workplaces and all work activities in Great Britain (that is the UK excluding Northern Ireland). In Northern Ireland the **Health and Safety at Work (Northern Ireland) Order 1978** achieves the same end.

The Act is very general in its coverage and flexible in terms of interpretation. Rather than focusing on fine detail and being prescriptive about exactly what must be done in specific workplaces it takes a broad view. It recognises that many different parties influence standards of health and safety in workplaces and it then assigns duties to those parties (making them **duty holders**). No specific detail is given to each duty holder about exactly what they must do to achieve compliance. Instead each duty holder is given some general aims to achieve. In this way the Act is an example of 'goal setting' legislation rather than 'prescriptive' legislation.

The Act is made up of over 80 sections. In the following pages the key sections of the Act are outlined (Sections 2 - 9 and Sections 36 and 37) and the duty holders and their duties are identified.

The Employer's Duty to His Employees

Section 2 of the Act states the duties of the employer towards his employees. This section is broken down into a number of sub-sections.

Section 2(1)

Section 2 (1) states the general duties of the employer towards his employees:

> *"to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees".*

This general duty is worth examining in more detail:

- The duty holder is the employer.
- They owe the duty only to their employees.
- They must ensure health, safety and welfare. (These three things have been defined earlier in this element.)
- The employer does not have to ensure absolute health or absolute safety. This would require that the employer provided a workplace free of all risk (i.e. a zero-risk environment). Instead the employer's duty is qualified by the phrase "so far as is reasonably practicable". This is a key phrase.

So Far As Is Reasonably Practicable

As mentioned above the employer is not required to provide a risk-free or zero-risk workplace. Such an environment does not (and cannot) exist. There is risk associated with all places and activities in life. Even simple tasks such as putting on clothes involves an element of risk to safety (the number of people visiting the Accident and Emergency department at their local hospital because of injuries sustained when getting dressed in the morning is quite surprising!). Similarly everyone is exposed to health risk all of the time (e.g. exposure to background radiation, which is always present in all locations, increases the risk of cancer).

Therefore, the employer's duty is **qualified** by the phrase so far as is reasonably practicable. This phrase has been defined by case law.

Topic Focus

So far as is reasonably practicable

This means that the duty holder must assess the degree of risk against the sacrifice involved in introducing control measures to eliminate or control the risk. This sacrifice can be measured in terms of financial cost, time and effort.

If it can be shown that there is gross disproportion between the risk and the sacrifice then the sacrifice does not have to be made.

Illustration of 'Reasonably Practicable'

So, for example, no-one worries about the risk of paper cuts in an office environment because the risk is trivial compared to the difficulty of eliminating or controlling the risk (what could you do – make all office workers wear cut-resistant gloves?). But employers do have to avert the risk of falls from height when workers are fixing the roof to a large steel frame building because the risks are clearly very high. Therefore, a lot of time, trouble and money has to be dedicated to controlling this risk.

Shall and Practicable

There are two other important phrases that are used to impose a duty in statute law: "shall" and "so far as is practicable".

Topic Focus

Shall **– an "absolute" duty**

When the word '*shall*' is used in statute law it creates an absolute duty. This means that the requirement must be met and there is no acceptable excuse for not doing so.

Practicable

When the phrase '*so far as is practicable*' is used in statute law it means that the duty must be complied with to the extent that it is possible to do so in the light of current knowledge and invention. So if it is possible then it must be done (irrespective of cost). If it is not possible then it does not have to be done.

Section 2(2)

Section 2(2) states the **specific duties** of the **employer** to his employees. It adds a little more detail to flesh out what the employer must do. Each requirement is qualified by the phase "so far as is reasonably practicable".

Topic Focus

The Employers specific duties to his employees are to provide:

2(2)(a) Safe plant and systems of work.

2(2)(b) Safe use, handling, storage and transport of articles and substances.

2(2)(c) Information, instruction, training and supervision.

2(2)(d) A safe workplace and safe access to it and egress from it.

2(2)(e) A safe working environment with adequate welfare facilities.

Note that the above is an abbreviation of the wording of the Act.

This section does not provide any detail for the employer on exactly how to achieve these ends. For that the employer has to turn to the regulations and their accompanying Approved Codes of Practice and Guidance. For example, requirement 2(2)(b) - to provide use, handling, storage and transport of articles and substances - does not state exactly what should be done when handling hazardous substances such as organic solvents. But the **Control of Substances Hazardous to Health Regulations 2002** and their accompanying ACoP and guidance do give very clear indications of what must be done to ensure safety.

Section 2(3)-2(7)

- **Section 2(3)** requires an employer to prepare a **written health and safety policy** that will include a general statement of policy and the organisation and arrangements for carrying it out. This policy must be revised as necessary and brought to the attention of employees.

  Subsequent legislation has made a written policy a legal requirement where the employer has five or more employees.
- **Section 2(4)** concerns the **appointment of safety representatives** by recognised trade unions.
- **Section 2(6)** requires employers to **consult with safety representatives**.
- **Section 2(7)** requires employers to establish a **safety committee**.

These last three sections will be examined in more detail in Element 3.

The Employer's Duty to Others

Section 3 places a duty on employers to ensure, so far as is reasonably practicable, that non-employees are not exposed to risks to their health and safety.

- The duty holder is the employer.
- They owe the duty to everyone else who is not an employee (clients, visitors, contractors, the public, etc.).
- They must ensure health and safety.
- The duty is qualified by "so far as is reasonably practicable".

Section 3 also places the same duty on the **self-employed**. They must carry out their work so that they do not create risk to themselves or others.

Controllers of Premises

Section 4 imposes duties on those who have some degree of control over non-domestic premises that they are making available for others (non-employees) to use as workplaces or for work activities. These persons can be referred to as "controllers of premises". A typical example would be a landlord or commercial property management company that owns and rents an office block for various other companies to occupy.

The controller of premises' duties are to ensure, so far as is reasonably practicable, that:

- The premises are safe.
- The means of access and egress are safe.
- Any plant or substances provided by them for use in that premises are safe.

Designers, Manufacturers, Importers and Suppliers Duties

Section 6 details the duties on any person who designs, manufactures, imports or supplies any article or substance for use at work.

These duty holders must ensure that:

- Any article or substance will be safe to use.
- Adequate **testing** takes place to ensure that it will be safe.
- The end-user is provided with **information** on safe use.
- The end-user is provided with revisions of that information as necessary.

Employee's Duties

Topic Focus

Section 7 of the Act states that it shall be the duty of every **employee**:

- To take **reasonable care** for the health and safety of **himself** and of **other persons** who may be affected by his **acts or omissions** at work.
- To **co-operate** with the **employer** to enable compliance with legal requirements.

Interference and Misuse

Section 8 states that no person shall intentionally or recklessly interfere with or misuse anything provided in the interests of health, safety or welfare in pursuance of legal requirements.

The expression "no person" implies that the duty is not limited to employees.

Free of Charge to Employees

Section 9 states that the employer cannot charge his employee for things done to achieve legal compliance. (Note that this prohibition on charging has many caveats.)

Offences Due to Fault of Others

Section 36 states that where an offence committed by a company is due to the act or default of some other person (e.g. advice from a consultant or safety officer), that other person (consultant or safety officer) may be charged with and convicted of the offence (whether or not proceedings are taken against the company itself).

Personal Liability of Directors and Senior Managers

Section 37 states that senior members of the management of a company **as well as** the company itself (body corporate) may be **personally liable** for breaches of the law. Directors and senior managers can be prosecuted for offences committed by the company if it can be shown that they consented, connived or were negligent in their duties in allowing the offence to be committed.

More...

The full version of **HSWA** can be obtained from http://www.opsi.gov.uk

Revision Questions

18. What is the difference between an absolute duty and a qualified duty, and how may the duty be qualified?

19. State the general duties of employers to employees under Section 2 of the **Health and Safety at Work, Etc. Act 1974**.

20. Explain the meaning of the phrase "so far as is reasonably practicable".

21. State the duties of employees under the **Health and Safety at Work, Etc. Act 1974**.

(Suggested Answers are at the end of Unit NGC1.)

The Management of Health and Safety at Work Regulations 1999

Key Information

- The **Management of Health and Safety at Work Regulations 1999** place various duties on an employer.
- Foremost amongst these is the requirement to carry out a suitable and sufficient risk assessment.
- The employer must also make arrangements for health and safety management; develop procedures to deal with imminent danger; provide health surveillance, information and training to employees; provide information to other employers and co-operate and co-ordinate with those who share their premises.
- Employees are also given duties.
- New and expectant mothers and young people are identified as two vulnerable groups who have to be given a higher level of protection through the risk assessment process.

Scope

The **Management of Health and Safety at Work Regulations 1999** (**MHSWR**) cover the same geographic area as **HSWA** and cover all workplaces and work activities. They contain more specific and detailed requirements; in particular about risk assessment and management issues such as the provision of training and information. In effect they add detail to certain parts of the framework created by **HSWA**.

The **MHSWR** are published by HSE as the Regulations accompanied by ACoP and Guidance. This document (L21) can be sourced from HSE Books (http://books.hse.gov.uk).

Hints and Tips

Note that in the following section, regulation numbers are given in brackets after each requirement. These regulation numbers do not need to be remembered for exam purposes; they are simply included to allow cross-referencing back to original text if necessary.

The Employer's Duties

Most duties contained in **MHSWR** fall on the employer.

Risk Assessment (Reg. 3)

- The employer shall make a suitable and sufficient assessment of the risks to both his employees and non-employees.
- The assessment must be recorded if the employer has five or more employees.
- The assessment must be reviewed.

Risk assessment will be examined in detail in Element 4.

Note that it states in **MHSWR** that an employer shall carry out a suitable and sufficient risk assessment, the regulations make it an **absolute** duty for the employer to comply.

Principles of Prevention to be Applied (Reg. 4)

- In implementing any preventive and protective measures, the employer must do so on the basis of some principles of prevention listed in Schedule 1 to **MHSWR**.
- This Schedule is, in effect, an appendix to the regulations and has full legal status.

The principle of prevention will be examined in detail in Element 4.

Health and Safety Arrangements (Reg. 5)

- The employer must make arrangements for the effective planning, organisation, control, monitoring and review of the preventive and protective measures.
- These arrangements must be recorded where the employer has five or more employees.

The concepts of safety management systems and safety policies both relate to this regulation and will be examined in detail in Element 2.

Health Surveillance (Reg. 6)

- The employer must ensure that employees are provided with appropriate health surveillance.

Health surveillance is usually a legal requirement of the regulations governing specific hazards. For example, audiometry is a legal requirement under the **Control of Noise at Work Regulations 2005**. The health surveillance requirements for various hazards are discussed later.

Health and Safety Assistance (Reg. 7)

- The employer must appoint one or more **competent person** to assist him in undertaking the measures he needs to take to comply with health and safety law.
- A competent person is someone with sufficient **training** and **experience** or **knowledge** and other qualities to enable him to give proper assistance.

Procedures for Serious and Imminent Danger and Contact with External Services (Regs 8 and 9)

- The employer must develop procedures to be implemented in the event of **serious and imminent danger**.
- They must nominate a sufficient number of competent persons to implement these procedures.
- They must ensure that any necessary **contacts** with external services are arranged, such as first-aid, emergency medical care and rescue work.

Information for Employees (Reg. 10)

The employer must provide his employees with comprehensible and relevant **information** on:

(a) The risks to their health and safety.

(b) Preventive control measures.

(c) Emergency procedures.

Co-operation and Co-ordination Where Two or More Employers Share A Workplace (Reg. 11)

Where two or more employers share a workplace each employer must:

- **Co-operate and co-ordinate** with the other employers to ensure health and safety.
- **Inform** the other employers of the risks to their employees' health and safety arising from his undertaking.

Information for Other Workers (Regs 12 and 15)

- The employer must provide other workers (who are not his employees) with **information** on the risks to their health and safety and preventive control measures.

  This means that contractors working on an employer's premises must be provided with essential health and safety information.

- Workers on temporary contracts must be provided with information about any specific qualification and health surveillance requirements.

Capabilities and Training (Reg. 13)

- The employer must take into account the capabilities of employees when allocating tasks.
- The employer must provide adequate **health and safety training** when employees are:
  - First recruited.
  - Exposed to new or increased risks.
- Training should be repeated periodically where appropriate and should take place during working hours.

Employee's Duties (Reg. 14)

The **MHSWR** expand upon the general duties placed on **employees** by **HSWA.**

Topic Focus

Employees must:

- Use equipment and materials in accordance with any instruction and training given.
- Inform the employer of any work situation that represents serious and immediate danger to health and safety or any shortcomings in the employer's arrangements for health and safety.

Protection of New and Expectant Mothers (Regs 16-18)

Jargon Buster

New mother

A new mother is a woman who has just given birth, up to 6 months after the birth, or while still breastfeeding. An expectant mother is a pregnant woman.

- Where work could present a risk to new or expectant mothers, a risk assessment must consider this.
- Where a risk cannot be avoided, the employer must alter working conditions and hours to avoid the risk.
- Where this would not avoid the risk, the employer must suspend the worker on full pay.
- The employer may have to suspend a night-shift worker if notified by a medical practitioner.
- The employer does not have to take any of the above preventive actions until notified in writing about the employee's status.

The specific hazards that present risk to new and expectant mothers are described in Element 4.

Protection of Young Persons (Reg. 19)

Jargon Buster

Young Persons

A young person is defined in **MHSWR** as anyone under the age of 18.

- The employer must ensure that young persons at work are protected from any risks to their health or safety.
- The specific characteristics that put a young person more at risk are:
  - Their lack of experience.
  - Their poor perception of risk.
  - Their physical and mental immaturity.

The protection measures appropriate for young persons are outlined in Element 4.

More...

The full text of the **MHSWR** and the ACoP (L21) can be downloaded from http://books.hse.gov.uk

Revision Questions

22. State the legal duty for recording risk assessments.

23. What specific types of procedure must the employer develop under **MHSWR**?

24. Define a "young person".

(Suggested Answers are at the end of Unit NGC1.)

Contractor Management

Key Information

- When a client takes on the services of a contractor both parties have shared responsibilities for ensuring good standards of health and safety.
- The client must carefully select contractors on the basis of their health and safety competence. This can be done by looking at the contractors' policy documents, accident and enforcement history, references, qualifications and experience.
- The client must ensure that contractors carry out risk assessments and develop method statements for their work. The client must monitor contractors to ensure that they work safely to agreed methods.
- The **Construction (Design and Management) Regulations 2007** (**CDM**) impose a framework for the management of construction projects. For notifiable projects the **CDM Regulations** identify five duty holders who each have specific duties assigned to them: the Client, the Designer, The CDM Co-ordinator, the Principal Contractor and Contractors.
- The regulations require the preparation of a Construction Phase Plan and a Health and Safety File for the finished structure.

The Client/Contractor Relationship

Contractors are engaged by clients in lots of different circumstances at work. A contractor may be engaged to perform a one-off service, such as the refitting of an IT suite, or they may be engaged on a more permanent basis to provide in-house catering or cleaning services. Quite clearly it is not in the interest of health and safety for the client to ignore the risks associated with the contractor's work or for the contractor to ignore the risk inherent in the client's workplace.

This section outlines some simple principles for the management of the contractor/client relationship. It then moves on to the specific issue of the management of construction projects under the **Construction (Design and Management) Regulations 2007** (**CDM**).

Jargon Buster

Contractor and Client

Contractor – a person or organisation engaged to undertake certain work on behalf of a client but not under the client's direct supervision and control.

Client – a person or organisation who engages a contractor.

Shared Duties

Contractors are responsible for their own health and safety and the health and safety of others who might be affected by their work activities.

As noted earlier, in the section on **HSWA**, a **contractor company** (such as a cleaning company) is an **employer** in their own right. They therefore owe a duty to:

- Their employees (the individual contract cleaners doing the work in a client's premises) because of Section 2.
- Other people (such as the client's employees and visitors to the client's premises) who might be affected by their work, because of Section 3.

And the **individual cleaners** doing the work in the client's premises are **employees** of the contract cleaning company. They therefore owe a duty:

- To themselves; and
- To other people (such as fellow workers, the client's employees and visitors to the clients premises) who might be affected by their acts and omissions, because of Section 7.

But we also noted earlier that the **client** (as an **employer**) owes a duty to:

- His own employees because of Section 2; and
- Others who might be affected by his undertaking because of Section 3.

- These others would include:
  - The contract cleaners in the premises.
  - Any other workers in the premises (such as other contractors).
  - Visitors to the client's premises.

Importantly, case law exists which clearly indicates that when a client brings a contractor onto site the contractor's work becomes a part of the client's undertaking.

The individual **employees** of the **client** also owe a duty:

- To themselves and
- To other people (such as contract cleaners, fellow employees, visitors) who might be affected by their acts or omissions because of Section 7.

Put simply, the contractor and his employees owe a duty to everyone and the client and his employees also owe a duty to everyone.

The above does not take into account each party's duties under **MHSWR** to carry out risk assessment, provide information and training, etc.

The responsibility for ensuring health and safety is therefore **shared** between the client and the contractor. It is in both parties' interests to ensure that each does everything that might be considered **reasonable** in the circumstances to discharge their duty and avoid criminal liability.

The way that a client manages contractors can be broken down into three key areas:

- Select the contractor.
- Plan the work.
- Monitor the work.

More...

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

The Selection of Contractors

Topic Focus

Selecting the Contractor

It is good practice to select a contractor carefully on the basis of their health and safety competence. To help in this you can ask to see evidence of competence, such as:

- A copy of their health and safety policy.
- Examples of risk assessments.
- The qualifications and training records of staff.
- Membership of a professional organisation or certified body.
- Records of maintenance and testing for plant and equipment.
- Names of previous or current clients.
- Accident history records.
- Records of enforcement action taken by authorities against them.
- Proof of adequate resources, such as access to specialist safety advice.
- Proof of adequate insurance.

Planning and Control of Contractors

Planning the Work

Information must be exchanged between the client and the contractor. The client should tell the contractor about the hazards and risks in the workplace, and the contractor should tell the client about the hazards and risks created by the contract work. In this way the work can be planned so that everyone is kept safe.

The contractor should carry out risk assessments on the work involved and develop safe working methods to control the risks identified. This safe working method must be documented and is often referred to as a "method statement".

Monitoring the Work

Arrangements must be made by the client to ensure the contractor complies with safe working practices. These arrangements should include:

- Having a signing in and out procedure.
- Ensuring that the contractor provides a named works foreman.

- Carrying out site induction training for all contractor workers.
- Controlling high risk activities with a permit-to-work system.

The client will need to monitor the contractor's work to ensure that the contractor is working to agreed safety standards. This can be done by monitoring against the method statement that was developed during the planning stage.

A client checks a contractors work against the agreed method statement.

Management of Construction Projects

Construction projects usually involve many different parties in a collaborative effort. Each party has a role to play in ensuring that the project is carried out safely and that the end result (the structure) is safe.

All construction projects are subject to the **CDM Regulations**. These regulations are split into various parts, some of which deal with the practical control of construction work. The following section deals with **notifiable** projects where all parts of the regulations apply.

Notification

A notifiable project is one where the construction phase is planned to:

- Last over 30 days or
- Involve more than 500 person days.

If a project falls in to one or both of these categories then a notification has to be sent to the HSE detailing:

- The address of the construction site.
- Brief description of project and construction work involved.
- Contact details of client.
- Contact details of CDM Co-ordinator.
- Contact details of Principal Contractor.
- Planned date for the start of the construction phase and its planned duration.
- Time allowed for planning and preparation for construction work.
- Estimated maximum number of people at work on the site.

CDM Duty Holders

For notifiable projects the **CDM Regulations** identify five duty holders who have a part to play in ensuring safety:

- **Client** - for whom the project is being carried out.
- **Designers** or architects - who specify the finished structure.
- **CDM Co-ordinator** - who assists the client during the planning and construction phases of the project.
- **Principal Contractor** - who manages the construction phase of the project.
- **Contractors** - who carry out specific types of work under the direction of the principal contractor.

The regulations also require the preparation of a 'Construction Phase Plan' and a 'Health and Safety File' for the finished structure.

The regulations assign the following duties to each party:

- The **Client** should ensure that:
  - All other parties are competent.
  - Adequate information is passed on to the other duty holders.
  - Work does not start until a construction phase plan for the project exists.
  - Adequate arrangements are made to ensure health, safety and welfare during the construction phase.
  - Any structure intended for use as a workplace complies with the **Workplace (Health, Safety and Welfare) Regulations 1992**.
- The **Designers** should ensure that:
  - The client is aware of his duties under the **CDM Regulations**.
  - A CDM Co-ordinator has been appointed for notifiable projects.
  - The design minimises health and safety risks to the construction workers; those who will occupy the structure on completion; and those involved in cleaning and maintenance.
  - The design for a structure intended for use as a workplace complies with the **Workplace (Health, Safety and Welfare) Regulations 1992**.
- The **CDM Co-ordinator** should ensure that:
  - The Client is advised on the adequacy of the arrangements put in place by other duty holders.
  - The HSE are notified of the project.

   - The client is advised on the appointment of competent contractors and designers.
   - Proper co-operation and co-ordination takes place during the design and planning process.
   - The health and safety file is prepared and passed to the Client at the end of the project.
- The **Principal Contractor** should ensure that:
   - A construction phase plan for the project exists.
   - The construction phase of the project is carried out safely.
   - The site is secure.
   - All contractors are working to the site rules.
   - All contractors receive site-specific induction training.
- The **Contractors** should ensure that:
   - They work to site rules.
   - They co-operate with the main contractor.

Designers and main contractors must carefully assess the safety implications of any changes to the design – both for construction workers and for end-users.

The Construction Phase Plan

The Construction Phase Plan is the health and safety management plan for the construction phase of the project.

The plan will be started by the CDM Co-ordinator and then developed by the Principal Contractor. Typical contents would include:

1. **Site description**
   - Including project description and existing site plans.
2. **Management of the work**
   - Management structure.
   - Management arrangements; such as arrangements for site induction and accident reporting.
   - Site rules.
   - Fire and emergency procedures.
3. **Arrangements for controlling significant site risks**
   - Safety risks, such as fall prevention.
   - Health risk, such as removal of asbestos.
4. **The Health and Safety File**
   - Arrangements for gathering and storing information.

Once the construction phase of the project starts, the main contractor has several responsibilities including:

- Setting site rules which subcontractors must obey.
- Monitoring compliance with and enforcing agreed site rules.

The overall site and all other contractors are under his control.

The Health and Safety File

The Health and Safety File contains information about the new or modified structure that the client needs to know.

Typical content would include:

- Brief description of work.
- Residual hazards.
- Key structural principles.
- Hazardous material used.
- Information relevant to dismantling.
- Information on cleaning or maintenance of equipment.
- Services.
- Info and as-built drawings of the structure and plant and equipment.

Revision Questions

25. List the criteria that might be used to assess the suitability of a contractor to undertake work on behalf of a client.

26. What types of construction project are notifiable projects?

27. What are the main duties of the following parties under the CDM Regulations?

    (a) The client.

    (b) The CDM Co-ordinator.

    (c) The principal contractor.

(Suggested Answers are at the end of Unit NGC1.)

Summary

This element has dealt with some of the basic principles of workplace health and safety.

In particular this element has:

- Explained that health and safety is a multi-disciplinary topic that requires knowledge across a wide range of subjects and that there are barriers to the raising of health and safety standards in a workplace.
- Introduced some of the key words and phrases that will be used throughout this course, such as health, safety, welfare and environmental protection.
- Highlighted the three main reasons why an organisation has to manage health and safety, which can be summarised as moral, economic and legal.
- Identified some of the direct and indirect costs associated with accidents and ill-health, some of which will be uninsured.
- Examined the framework created by the criminal and civil legal systems and the characteristics of both types of law.
- Outlined the two sources of law as statute law, made by parliament, and common law, made by judges.
- Outlined the structure and hierarchy of the criminal and civil courts.
- Described the power of HSE inspectors under **HSWA**, the characteristics of Improvement and Prohibition Notices they might issue and the penalties for breaching the Act.
- Explained the basic principles of the civil legal system, such as vicarious liability, the proofs required for Tort of Negligence and Tort of Breach of Statutory Duty and the defences available, such as contributory negligence.
- Examined the key sections of **HSWA** such as the Section 2 duty owed by an employer to his employees to ensure, so far as is reasonably practicable, their health safety and welfare at work.
- Outlined the meaning of the phrase "so far as is reasonable practicable".
- Outlined the other duty holders identified in the Act such as the self-employed, controllers of premises, designers and manufacturers, and employees.
- Outlined the liability of directors, senior managers and external advisers for offences committed by an organisation.
- Identified the key legal requirements of the **MHSWR**, in particular the requirement for the employer to carry out a suitable and sufficient risk assessment.
- Identified new and expectant mothers and young people as two vulnerable groups who are given special mention in **MHSWR**.
- Explained the shared responsibilities that exist when work is carried out by contractors for a client.
- Outlined a basic framework for the selection, monitoring and control of contractors by clients.
- Described how the **CDM Regulations** impose a framework for the management of construction projects; the five duty holders identified for notifiable projects; and the requirements to prepare a Construction Phase Plan and a Health and Safety File.

NEBOSH Certificate Unit NCC1

Element 11: Excavation Work and Confined Spaces - Hazards and Control

RRC TRAINING

Contents

Learning Outcomes

On completion of this element, you should be able to demonstrate understanding of the content through the application of knowledge to familiar and unfamiliar situations. In particular you should be able to:

- Describe the hazards and risks of excavation work.
- Describe the appropriate control measures for excavation work.
- Define a confined space and describe the hazards and risks associated with confined space working.
- Describe the appropriate control measures for confined space working.

Excavations Hazards and Assessment

Key Information

- The hazards of excavations are: collapse of sides, striking buried services, falls and falling objects, collapse of adjacent structures, flooding, contaminated ground, toxic and asphyxiating atmospheres and mechanical hazards.
- Risk assessment factors to consider are: depth, type of soil, type of work, use of mechanical equipment, proximity of roadways and structures, the presence of the public and weather conditions.

Hazards of Work In and Around Excavations

The hazards associated with excavation work include:

- **Buried services** – striking services such as high voltage electricity cables, gas pipes, mains water or other buried services (e.g. telephone and cable TV lines). This can lead to electric shock, arcing, burns and fire, or gas explosion or rapid flooding of the excavation, as well as major business disruption to service users in the area.

A shallow excavation revealing a collection of buried services

- **People falling in:**
  - Because of an unfenced edge.
  - While climbing in or out from ladders or other access equipment.
- **Objects and materials falling in**, e.g.:
  - Tools or materials (bricks, timber, etc.) falling into an excavation onto persons, from an unprotected edge.
  - Vehicles driving too close to the side of an excavation, collapsing the sides or tipping in.
  - Spoil (loose soil) or stacked loose sand piled too close to the sides of an excavation.
  - Adjacent structures (e.g. wall or scaffold) undermined by an excavation and collapsing in.
- **Collapse of sides** – when the unsupported sides of an excavation slip and cave in (often due to poor support systems of the excavation sides). Severe crush injuries can result from even relatively small collapses because soil is very heavy, especially when wet. Workers buried or trapped in soil can asphyxiate in minutes, and do not have to be completely buried for this to occur; being buried up to the chest can lock the rib cage and have the same effect.
- **Flooding:**
  - From surface water during heavy rain or snow.
  - From groundwater (a high area water table), nearby rivers, streams and watercourses (especially if breached).
  - From a burst water main caused by the excavation activities.
- **Contaminated ground:**
  - On sites that previously housed chemical works or storage areas.
  - Containing methane or hydrogen sulphide gas (both from microbial decay).

Contaminants can be varied in range and include:

Industry	Possible Contaminant
Petrochemicals	Hydrocarbons, benzene, phenol, acids, alkalis
Steel/iron works	Iron, copper, zinc, asbestos
Gasworks/power stations	Coal, sulphur, phenol, asbestos, cyanides
Pits/quarries	Leachates, copper, zinc, lead, methane
Tanneries	Anthrax
Miscellaneous industries	Polychlorinated biphenyls, sulphates, metals, micro-organisms

- **Toxic and asphyxiating atmospheres** – from sources mentioned above, and from gases used on site.
  - Heavier than air, gas such as LPG and carbon dioxide can infiltrate an excavation.
  - The combustion gases from nearby construction equipment such as diesel generators and motor vehicles can seep into excavations with the same effect.
- **Mechanical hazards** - mainly from the use of plant and equipment around or in the excavation.
  - Vibration from plant operating may cause collapse.
  - Excavating machinery itself may create hazards, such as striking persons in or around excavations.

Risk Assessment

Risk assessments should be carried out in accordance with the **Management of Health and Safety at Work Regulations 1999**, with due consideration to the excavation under the **Construction (Design and Management) Regulations 2007**.

Topic Focus

Risk assessment - factors to consider:

- Depth of the excavation.
- Soil type – this may vary from fine sand which can flow easily, to heavy clay which is much more cohesive.

  Three broad classes of ground exist:
  - Non-cohesive ground or light soil, e.g. sand or gravel, whose natural angle of repose (see later) when dry is usually 45° or less.
  - Cohesive ground or heavy soil, e.g. stiff clay, whose natural angle of repose is about 60°.
  - Rock, whose natural angle of repose varies from about 80° for loosely bonded or light rock, to 90° for tightly bonded heavy rock. Rock may, however, have steeply sloping clay planes which may fail, with resultant collapse.
- Type of work involved, e.g. at the side of a road; in a housing development; laying pipes/cables; trenches; pits.
- Use of mechanical equipment – the types being used.
- Proximity of the excavation to roadways, watercourses, structures, schools, hospitals.
- Presence of the public/children.
- Weather – summer, winter.

Revision Questions

1. What hazards are associated with work in and around excavations?
2. What factors should be taken into account with regard to risk assessments for excavations?

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

Control Measures for Excavation Work

Key Information

- Precautions must be taken to prevent persons falling into, or being injured while working in, excavations.
- These include:
  - Identifying buried services and using safe digging methods to avoid contact with them.
  - Supporting the sides of excavations to prevent collapse, and providing workers with suitable access and egress, and crossing points to pass over excavations.
  - Barriers, lights and signs used to demarcate danger areas.
  - Spoils (the ground dug from an excavation) to be removed to and stored at a safe distance from the excavation to prevent it collapsing back in.
  - De-watering and freezing methods used to remove water from excavations.
  - Vehicles and materials on site kept away from excavations to prevent them falling into or collapsing the excavation.
  - Workers in excavations wearing items of PPE – safety helmets, safety footwear, respirators or breathing apparatus, hearing protection.
  - Testing for contaminated ground and providing extra welfare facilities to accommodate workers (separate from normal site facilities). Health surveillance may be appropriate for contaminants such as asbestos, lead or radioactive materials.
  - Excavation supports to be inspected before each shift, and after any event that could affect the integrity of the excavation, and reports to be made and kept.

Controls

In common with other construction activities, control of the risks involved in excavation is based on effective management. The **CDM Regulations** apply in this respect, and excavations must be carried out under the supervision of a competent person.

Identification, Detection and Marking of Buried Services

The location and configuration of underground services should be identified prior to work commencing. It may well be possible to avoid cable routes at the planning stage of work. Before work starts, the following action should be taken:

- Check any available plans.
- Contact local services providers and owners such as electricity, gas, water, telecommunications or TV companies.
- Survey the site and surrounding areas to identify indicators of the existence of cables, etc. – e.g. streetlights or junction boxes.
- Use cable locators with trained operators. Plastic and non-metallic underground services cannot be identified by conventional locators, but could be identified by the use of metallic tracer wire laid with the pipe or by using a signal transmitter inserted and pushed along the pipe itself.

The positions of known services should be marked on plans and also on the ground itself. All employees must receive adequate information and instruction about the nature of the risks.

Where appropriate, arrangements must be made with the services providers to isolate the cables/pipes and ensure that it is safe to work in the vicinity of them.

Safe Digging Methods

These include:

- Using locators to determine the position and route of pipes or cables (frequently using them during the course of the work).
- Keep a careful watch for evidence of pipes or cables. Remember that plastic pipes cannot be detected by normal locating equipment.
- If contact is made with any unidentified service pipe or cable, stop work until it is safe to proceed.
- Regard all buried cables as live until disconnected and proven – pot-ended cables cannot be assumed to be dead or disused.

- Excavators and power tools should not be used within 0.5 metres of the indicated line of a cable/ pipe.
- Hand digging should be employed when nearing the assumed line of the cable/pipe.
- Spades and shovels (preferably with curved edges) should be used rather than other tools, e.g. forks, picks.
- Report any damage to the appropriate services and keep personnel clear until it is repaired.
- Have an emergency plan to deal with such damage to pipes or cables.
- Exposed cables and pipes should be supported and protected against damage by backfilling. They should never be used as hand- and foot-holds.

Methods of Supporting Excavations

Excavation supports will prevent the collapse of the side walls of the excavation and allow work to continue uninterrupted inside the workings. The type of support structure used will vary, depending on:

- Type of ground being excavated.
- Length of time the excavation will be open and in use.
- Type of work being carried out.
- Groundwater conditions and potential for flooding.
- Depth of the excavation.
- Number of people in the excavation.

Types of excavation supports include:

- **Battering**

  This allows almost any excavation to be dug without the need for a support system. It relies on the properties of the soil into which the excavation is being dug to form a stable, sloping pile when allowed to form naturally into heaps. The sloping surfaces of the heap form an angle with the horizontal called the angle of repose. Each material has its own particular **angle of repose** which will differ according to the amount of moisture it contains.

Angle of Repose

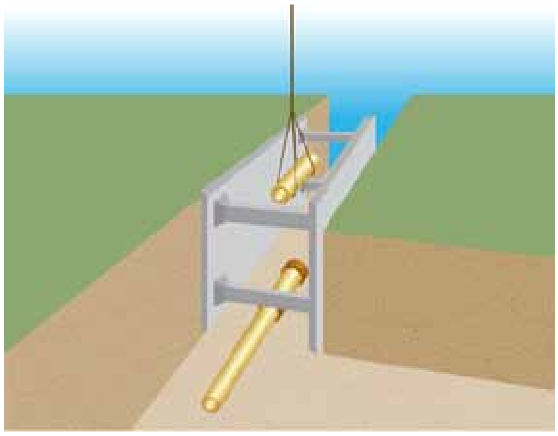
As the excavation is dug out, the sides are sloped back to less than the angle of repose (which has to be determined first) so that the soil will support itself without the need for extra support. This method requires considerable space to construct an excavation and is probably impractical in built-up areas.

- **Shoring**

  Steel sheets are laid across the faces of the excavation walls, secured together by clamps and braced by expandable steel struts or wooden beams. The steel sheets should be toed in at the bottom and rise above the tops of the trench sides.

Shoring the sides of an excavation by 'close sheeting'

Trench boxes (support boxes) are ready-constructed units which can be easily and quickly installed into an excavation, using an excavator or similar machine, to provide strong, reliable shoring for most ground conditions while giving full protection for operatives. They can be moved along as the work progresses.



A trench box placed inside a trench creates a protected area for workers

Where necessary, both types should have edge protection and a means of access via a protected area.

Means of Access

Ladders provide the main method for access to and egress from an excavation. They must be suitably secured to prevent undue movement and extend above the excavation to give the necessary height required for a safe handhold (at least 1.05 metres).

There must be adequate means of escape in an emergency: one ladder every 15 metres is an average to work to (more may be required depending on the number of workers and the potential risk – e.g. where there might be a possibility of flooding from a rising water table).

Ladders must be kept in good condition, be fit for the purpose and of adequate strength. Climbing in and out of the excavation using other means should be prohibited.

Crossing Points

Excavations should only be crossed at designated points. The crossing point should be of sound construction and suitable to support all the types of vehicle and equipment likely to use it. Gangways across excavations should have guardrails and toeboards.

Crossing Point

Barriers

These should consist of guardrails (as for a scaffold work platform) to prevent people falling in, and toeboards to prevent objects being kicked down into the excavation. In addition:

- To prevent vehicles from falling in, logs or concrete blocks are laid some distance from the edge, to act as a buffer.
- Excavations may need to be covered, particularly at night. Such covers need to be capable of bearing a person's weight and be held securely in place.
- Fencing or hoarding may be required to protect members of the public as well as construction employees.

Lighting and Warning Signs

Signs should be used to warn people of the excavation hazards, and any special precautions required. They should be placed in clearly visible spots at all potential access points.

Appropriate lighting should be installed to ensure that there is an adequate level of illumination, without distracting shadows, to ensure the safety of work activities both within the excavation and on the surface. High-powered electric lights or those which operate from liquid petroleum gas (LPG) will be required for general workplace illumination, and consideration may need to be given to smaller, personal lights for individual workers. These should be battery-operated to avoid the risks associated with trailing electrical leads.

When working on a roadway, the police or the local authority need to be consulted about traffic lights or stop/go signs. There are rules for the placing of cones to warn motorists of the hazard.

Safe Storage of Spoil

If this is to be left in spoil heaps near the excavation, there must be space to stack it without interfering with other operations, and leaving a clear area of 0.6 m between the spoil and the edge of the excavation. The officially recognised depth of the excavation depends on **the distance of the spoil heap from its edge**. For excavations up to 6 m deep, the following rules apply in the UK:

- If the spoil heap is within 1.5 m of the edge of the excavation, the depth of the excavation should be measured **from the top of the spoil heap**.
- If the spoil heap is more than 1.5 m from the edge (but less than the actual depth of the excavation), the official depth should be taken as **the actual depth plus half the height of the spoil heap**.

De-Watering and Use of Freezing Equipment

Preventing Water Entering Excavations

Water can fall as rain, snow and sleet directly into excavations, especially if they are uncovered. The run-off following these downpours can also run in. Water can enter through the sides depending on the height of the surrounding water table, and proximity of watercourses (rivers, streams, lakes, etc.) can cause excess water.

Accidental damage to nearby tanks, water mains or other supply pipework in the vicinity of the excavation can also lead to an ingress of water. All exposed pipes should be identified and supported.

To protect the stability of the sides of the excavation, drainage channels can be cut around the excavation and the water can be channelled away to sumps where it can be pumped away. The water table is then lowered below the level of the excavation. In extreme cases, watercourses might be redirected.

Excavation sides can be strengthened by using higher shoring and sandbagging the outside. However, the continued flow of water from the area surrounding the excavation may cause settlement problems.

Well pointing or deep wells can be considered where sandy or silty soil exists. Ground freezing or providing an impermeable barrier by injecting cement, bentonite or a chemical is an option, but can be expensive and cause disruption to the ground.

The disposal of any water should be discussed with the appropriate environmental agency.

Pipe Freezing

Pipe freezing uses a jacket that is clamped around a pipe and feeds liquid nitrogen into the jacket to freeze that section of pipe. Liquid nitrogen exposes workers to:

- Frost burns from the cold liquid/gas and the clamp and fittings.
- Inhalation of nitrogen gas, which can lead to loss of concentration, disorientation and possible asphyxiation.

Should a pipe leak or rupture during the process, the worker can also be exposed to the contents of the pipe.

Pipe freezing using liquid nitrogen should only be carried out under the controls of a permit-to-work, or in an area with restricted access. Only properly trained and competent workers should undertake this work. Equipment should be in place to pump out the contents of the excavation (both before freezing and if a rupture occurs) and forced ventilation used (e.g. a fan directing air across or into the excavation). Vented pipe-jackets should be used to apply the nitrogen, and oxygen levels should be continuously monitored.

Operatives should use cold-resistant (insulating) gloves (and all other appropriate PPE), and emergency procedures are needed to rescue persons injured or overcome by lack of oxygen. For this, trained rescue personnel will be necessary using breathing apparatus. All other precautions for work in excavations must be followed.

Positioning and Routeing of Vehicles, Plant and Equipment

To prevent vehicles and objects falling into excavations, and collapse of sides, the following precautions should be observed:

- Do not stack waste, spoil or building materials near the edge. Apart from the risk of falling material, the weight of stacks close to the edge may cause the walls of the excavation to collapse.
- Machinery and vehicles should only be operated in specially designated areas strong enough to withstand the effects of vibration without causing a collapse. Specially built routes to allow access to the floor of the site for vehicles and plant may have to be constructed.
- Where vehicles have to pass close to excavations, barriers and signs should be in place to keep them a safe distance away.
- Where vehicles have to approach the edges of the excavation (e.g. to receive or tip materials) there should be stop blocks to prevent them overrunning.

Personal Protective Equipment

Hard hats and safety footwear are a likely requirement at all times. The need for other PPE will be determined by the nature of the work carried out in the excavation. For example:

- Fumes and dust may require the use of masks and respirators.
- Excessive noise levels will require the wearing of hearing protection.
- Where welding work is carried out, face shields and protective clothing will be necessary.
- Breathing apparatus and safety harnesses may be required for working in tunnels and shafts.

Particular Requirements for Contaminated Ground

Soil Testing

Soil testing to show the presence of any contaminants must be carried out by competent persons from an accredited laboratory.

Once the nature of contaminants is established, measures can be put in place to limit the risk that might be present, e.g. PPE, hygiene facilities, safe systems of work, medical surveillance.

Great care must be taken as:

- Digging will uncover buried materials or contaminants within the ground which are hazardous to health.
- The contaminants themselves can change over time due to bacterial or chemical action, which may also alter their properties. This may be the result of the decomposition of organic matter or from the dumping or spillage of hazardous substances.
- Certain contaminants are subject to specific legislation, namely asbestos, lead, anthrax, radioactive materials and buried explosives, and well established procedures need to be followed to deal with each of these situations.

- There may be radioactive hazards from the ground itself (probably as a result of previous occupancy).
- Toxic and asphyxiating atmospheres may be present, e.g.:
  - Flammable gases such as methane (marsh gas) and carbon monoxide from plant and machinery used in connection with excavation, including pumps involved in de-watering operations.
  - Toxic gases such as hydrogen sulphide.
  - Chemicals and metal compounds, either in containers or within the soil.

Welfare Facilities

- Separate facilities (toilets, wash rooms and showers, rest and eating facilities) from the main facilities will be required for work involving contaminated sites.
- Specialist facilities may be required where work involves asbestos, lead or radioactive materials.
- Separate clothing accommodation and changing rooms may be required to prevent cross-contamination.
- These facilities must have adequate heating, lighting and ventilation.

Health Surveillance

Medical practitioners can screen the workforce involved (e.g. blood/urine testing) and provide continued monitoring to ensure that no serious medical conditions arise. The effect of screening can also alleviate any anxiety caused to either the workforce or the public as to whether the measures in place are adequate.

Inspection Requirements for Excavation Support

No person is allowed to work in an excavation (other than to examine it) until it has been competently examined.

The inspection of excavations and supports is required:

- At the start of each shift.
- After any event likely to have affected the strength or stability of the excavation (e.g. flooding).
- After any material unintentionally falls or is dislodged.

An inspection report must be made and kept (**CDM** Regulation 33).

- The report must be completed before the end of the shift in which the excavation was inspected.
- A copy of the report must be given to the person in charge of the worksite within 24 hours of completing the inspection.
- Reports must be retained at the site until the excavation work is completed and, after that, for three months.

Though excavations must be routinely inspected prior to each shift, no more than one written report is needed in seven days unless the strength or stability of the excavation is affected, e.g. after accidental falls of material.

Topic Focus

An **excavation inspection report** must contain:

- The date, time, location and a description of the workplace inspected.
- The name and position of the person inspecting/making the report.
- The name of the person on whose behalf the inspection was carried out (i.e. the person in charge of the worksite).
- Details of any matters identified that could give rise to health and safety risks, and any actions taken to control them.
- Details of any further actions considered necessary.

When work in the excavation is completed, support materials (timber, sheeting, etc.) should be safely removed by experienced workers and a competent person should inspect the site to ensure that all dangerous materials and equipment have been removed. Water may have to be pumped out of the excavation before it is filled.

Filling should use only appropriate materials and be conducted in a controlled manner under the direction of a competent person. Uncontrolled tipping is an offence.

Revision Questions

3. What controls may be necessary during excavation work?
4. What particular hazards may arise during the excavation of contaminated ground?
5. What inspection requirements are there for excavations?

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

Confined Spaces Hazards and Risks

Key Information

- Confined space is any enclosed space with a specified risk of injury associated with it, including trenches, sewers, chambers and pits.
- Hazards include toxic, explosive and oxygen-deficient atmospheres; heat and water; free flowing solids and restricted space.

Definition of 'Confined Space'

A confined space:

- Is any enclosed space where there is a reasonably foreseeable specified risk of any serious injury associated with it.
- Includes chambers, tanks, vats, silos, pits, reaction vessels, trenches, pipes, sewers, enclosed drains, flues, wells, open-topped chambers, combustion chambers in furnaces, ductwork or other similar spaces.

Other places become confined spaces:

- Due to the type of work undertaken, e.g. spray painting a room.
- As a result of a change in conditions inside the space, e.g. overheating in a plant-room or electricity sub-station.
- Due to a change in confinement or the degree of enclosure, e.g. inside an item of moving plant or machinery (such as a compactor or baling machine).

Topic Focus

"**Specified risks**" associated with work in confined spaces are risks of:

- Serious injury arising from fire or explosion.
- Loss of consciousness arising from an increase in body temperature.
- Loss of consciousness arising from asphyxiation due to gas, fume, vapour or lack of oxygen.
- Drowning arising from a free-flowing solid, e.g. flour, grain, sand, sugar, etc.
- The inability to reach a respirable environment due to entrapment by a free-flowing solid.

Typical Confined Spaces in Construction

Typical confined spaces found in construction work include trenches, sewers, manholes, tunnels, excavations, chambers, tanks, pits, cellars and unventilated rooms.

The **Confined Spaces Regulations 1997** lay down the legal requirements for work in confined spaces. These Regulations contain the following key duties:

- Avoid entry to confined spaces, e.g. by doing the work from outside.
- If entry to a confined space is unavoidable, follow a safe system of work and put in place adequate emergency arrangements before the work starts.

Due to the nature of the work itself, i.e. where there are risks from machinery, electricity or hazardous substances, other legislation may be involved as discussed in earlier elements.

Hazards and Risks Associated with Confined Spaces

Toxic Atmospheres

Poisonous gas, fumes or vapour can:

- Build up in sewers, manholes and pits.
- Enter tanks or vessels from connecting pipes.
- Leak into trenches and pits in contaminated land, e.g. old refuse tips and old gas works.

Certain toxic gases may be present:

- Hydrogen sulphide from sewers or decaying material.
- Carbon monoxide from internal combustion engines (petrol/diesel) or the incomplete combustion of LPG.
- Carbon dioxide:
  - From fermentation processes.
  - Naturally from the rocks/soil.
  - From combustion processes.

- Certain fumes/vapours could be present from chemicals, e.g. ammonia, chlorine or petrol/solvents.

Explosive or Flammable Atmospheres

Certain gases in small concentrations can pose a hazard and produce either a fire or an explosive atmosphere, e.g. LPG, acetylene, propane, butane, methane, hydrogen sulphide, acetone, toluene, alcohol, white spirit, thinners, solvents, hydrogen, depending on their explosive range in the atmosphere.

Confined spaces that need to be entered for cleaning or maintenance may have been used to store hazardous substances, e.g. toxic, flammable or explosive liquid or dust. These hazards must be addressed by procedures and equipment to eliminate harmful exposure to authorised entrants.

Oxygen-Deficient or Enriched Atmospheres

Oxygen depletion can occur:

- Through displacement (the addition of a gas or vapour to the space displaces the oxygen), e.g:
  - Purge gas.
  - Pipe freezing.
  - Gas leaking from elsewhere.
- Through consumption (oxygen in the atmosphere is depleted by a chemical reaction or biological process occurring in the space), e.g. oxidation, rusting, bacterial growth.
- Through welding operations.
- By people working.
- By any process of combustion.
- Where there is a reaction between some soils and the oxygen in the atmosphere.
- Following the action of groundwater on chalk and limestone - this can produce carbon dioxide and displace normal air.

Oxygen enrichment occurs:

- When oxygen is artificially introduced into a space.
- Where the chemical contents of a space release oxygen as they degrade.
- As a result of leaking equipment.

Any organic material, e.g. oil, grease, will become highly combustible and paper, material or clothing will burn fiercely. If an oxygen-enriched atmosphere is present, the space must be ventilated until normal oxygen levels are obtained.

Heat

Hot conditions can lead to a dangerous increase in body temperature and may result in:

- Heat stress, fatigue or exhaustion.
- Dehydration/loss of fluids.
- Loss of consciousness.

Precautions:

- Increasing the number of openings might improve ventilation.
- Adequate rest breaks and cool drinks may help to alleviate hot conditions.
- Mechanical ventilation:
  - May be necessary to ensure an adequate supply of fresh air.
  - Will be essential where portable gas cylinders and diesel-fuelled equipment are used inside the space, because of the dangers from build-up of engine exhaust.

Water

Work in confined spaces such as trenches, pits, sewers that contain standing water can lead to gastroenteritis, Weil's disease and hepatitis A or B. There are also the problems of water ingress and being drowned or swept away.

Additional precautions include:

- Weather forecasting.
- Establishing local on-site procedures to deal with large volumes of water and contingency plans to deal with such dangers.
- Safety harnesses and chain barriers across the water to prevent workers being washed away should be provided.
- The workers themselves must be aware of the personal hygiene requirements and the inoculations recommended for such working conditions.

Free-Flowing Solids

A person can drown or asphyxiate if immersed in any free-flowing solid such as cement or sand. The solid acts as a liquid because it cannot be breathed, possibly clogging the respiratory tract and entering the lungs, depriving them of oxygen.

Restricted Space

Where a space imposes exceptional constraints as a result of its physical layout (lack of space), suitable personnel should be selected to enter. They must:

- Be capable of doing the work.
- Be physically fit and agile.

- Not suffer from claustrophobia.
- Be able to wear breathing apparatus – medical advice on an individual's suitability may be needed.

The confined space may be further restricted by the equipment it contains and the tools and PPE used by the person entering. Liquids or solids can suddenly fill the space, or release gases into it, when disturbed. Free-flowing solids such as cement can also partially solidify or 'bridge' in silos, causing blockages which can collapse unexpectedly. If access to the space is through a restricted entrance, e.g. a manhole, escape or rescue in an emergency will be more difficult.

Some of the above conditions may be present in the confined space, some may arise from the work being carried out, or because of ineffective isolation of plant nearby, e.g. leakage from a pipe connected to the confined space.

The enclosure and working space may increase other dangers arising through the work being carried out, e.g.:

- Machinery being used may require special precautions, such as:
  - Provision of dust extraction for a portable grinder.
  - Precautions against electric shock.
- Gas, fume or vapour can arise from welding, or by use of volatile and often flammable solvents or adhesives.

Revision Questions

6. (a) What is the definition of a confined space?

   (b) Where are confined spaces found on a construction site?

7. What hazards are associated with confined spaces?

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

Control Measures for Confined Space Working

Key Information

- Ideally, persons should not enter confined spaces at all, but where they must, precautions must be taken to protect them.
- Risk assessment and planning will determine what precautions are appropriate.
- Precautions will include the use of a permit-to-work; training of competent personnel; and testing the atmosphere for contaminants.
- There must be a safe way in and out of a confined space, usable by persons wearing PPE, including rescue crews.
- Monitoring arrangements must be in place and procedures to deal with rescue and any other emergencies.

Precautions for Safe Entry

Avoidance Where Possible

Persons should not enter a confined space to carry out work unless it is not reasonably practicable to do it any other way. Better work-planning or a different approach can reduce the need for confined space working, e.g.:

- Modify the confined space itself so that entry is not necessary.
- Do the work from outside, e.g. blockages can be cleared in underground chambers by use of remotely operated rotating flail devices, vibrators or air purgers.
- Inspection, sampling and cleaning operations can often be done from outside the space using appropriate equipment and tools.
- Remote cameras can be used for internal inspection of vessels.

A safe system of work is always required to enter, carry out work and leave a confined space (other than in an emergency).

Risk Assessment

The **Management of Health and Safety at Work Regulations 1999** require a risk assessment to be carried out to identify the hazards present, assess the risks and determine what precautions to take. The **Confined Spaces Regulations 1997** apply, and the assessment will help to identify the precautions to be included in the safe systems of work required. Appropriate health surveillance must be offered where required.

Topic Focus

Confined space risk assessment will cover:

- Can confined space entry be avoided?
- Work needing to be done, e.g. routine or breakdown.
- Methods of working – tools and equipment to use.
- Entry with or without breathing apparatus.
- Hazard identification in the plant.
- Hazards from neighbouring plant/vessels.
- Suitability of those carrying out the work.
- Steps necessary to make the job safe, i.e. a safe system of work.
- Arrangements for emergencies and rescue facilities.

Planning

Preliminary planning of confined space entry is important to establish whether entry:

- Can be avoided or an alternative method used.
- Is required without breathing apparatus.
- Is required with breathing apparatus.

Proper planning will also help to establish effective lines of authority and communication so that the procedures put in place are clear and free from any misunderstanding or conflict of interest. The precautions necessary for each entry will vary with the nature, size, location, risks involved and the number of people working. However, the basis of the safe system of work will depend on each risk assessment carried out.

Permit-to-Work Procedures and Requirements

An employer must establish a permit system for controlling confined space entry, using competent personnel to ensure formal checks are undertaken, and putting in place a safe system of work before people are allowed to enter the confined space. A permit system is also a means of communication between site management, supervisors, and those carrying out the hazardous work.

Topic Focus

Essential features of a permit-to-work system are:

- Clear identification of who may authorise particular jobs (and any limits to their authority).
- Who is responsible for specifying the necessary precautions (e.g. isolation, gas testing, emergency arrangements, etc.).
- The inclusion of contractors engaged to carry out work.
- Training and instruction in the issue and use of permits.
- Monitoring and auditing to ensure that the system works as intended.

Requirements of Permit

The safe system of work based on the risk assessment should consider:

- Adequate, competent supervision.
- Experienced and competent workers.
- Proper isolation of plant and equipment.
- Pre-cleaning and correct disposal of debris and sludge.
- Adequate lighting (intrinsically safe) and ventilation.
- Atmospheric testing.
- Provision of specialist, non-sparking tools, breathing apparatus and rescue harnesses.
- Emergency arrangements/plans.

The **permit-to-work programme** incorporates the requirements laid out in the safe system of work and includes:

- **Hazard Identification**

  Each permit requires the confined space to be evaluated for its potential hazards and their severity, including surrounding plant and buildings.

- **Hazard Control**
  - Safe entry procedures and practices must be put in place.
  - The equipment or area may need to be withdrawn from service.
  - Warning notices should be displayed and all plant operators notified.
  - The person in charge of the process should be competent and sign the permit.

- **Isolation and/or Locking Off**
  - Plant should be physically disconnected from other items of plant.
  - Mechanical and electrical isolation of equipment is essential if it could otherwise operate, or be operated, inadvertently.
  - Lock-off systems should be used.
  - If gas, fume or vapour could enter the confined space, physical isolation of pipework, etc. needs to be carried out.
  - In all cases a check should be made to ensure isolation is effective.

Jargon Buster

Lock-Off System

This involves securing an electrical isolator (or other energy control handle, lever, pipe-valve, etc.) with a padlock so it cannot be switched on or operated. Each operative will apply their own separate padlock, and a safety sign ("tag") will be put on the locks.

- **Permit System**

  A written system for preparing, issuing and implementing permits for entry must be established. A separate and additional 'hot work permit' is required for operations which could provide a source of ignition, such as riveting, welding, cutting, burning or heating.

- **Employee Information**

  Signs that warn of the hazards and prohibit unauthorised entry must be posted on or near confined spaces.

- **Prevention of Unauthorised Entry**

  A combination of worker training, posting of signs, and utilisation of barriers must be employed as necessary.

- **Employee Training**

  Personnel directly involved with confined space entry, issuing permits-to-work, or entry supervision must receive specialised training.

- **Equipment**

  Testing, monitoring, communication and PPE necessary for safe entry and rescue must be provided, maintained, and used.

- **Rescue**

  Procedures, plans and equipment necessary for rescue must be in place. An employer must have a trained, in-plant rescue team or an arrangement with an outside team to respond upon request. Rescuers must have the same entry training as employees working in confined spaces. In addition to specific rescue training, they should attend a simulated rescue operation at least once every 12 months. If an outside rescue organisation is used then they must be made aware of the specific hazards they may encounter when responding to an emergency.

- **Protection from External Hazards**

  Steps must be taken to protect the entrant(s) from external dangers, e.g. placing vehicle barriers when the operation is adjacent to traffic areas.

- **Duty to Other Employers**

  Contractors hired to perform confined space entry must be provided with all relevant health and safety information they need to protect their employees' safety.

Topic Focus

A **sentry** must be present at all times during entry operations, maintain continuous contact with those inside, and order them to evacuate the confined space if one of the following occurs:

- A condition is observed that is not allowed in the entry permit (e.g. the development of a hazardous atmosphere caused by changing conditions or as a result of the work activity in the confined space).
- The sentry detects behavioural changes in the entrants that could be the result of harmful exposure.
- The sentry detects a situation outside the space which could endanger those inside.
- The sentry is monitoring more than one permit space and must focus attention on the rescue of the entrants from one of those spaces.
- The sentry must leave the workstation for any reason.

Procedures, plans and rescue equipment must be in place

Training and Use of Competent Persons

All persons involved with supervising or carrying out confined space work must have adequate training, which should be repeated regularly.

The training should involve the permit-to-work, respiratory equipment, gas-testing equipment, rescue procedures, first-aid treatment including artificial respiration, evacuation and emergency procedures, fire-fighting, and communication procedures. No person should be allowed to enter a confined space unless they are trained and competent to do so and records should be kept of all types of training carried out.

Atmospheric Testing

It is necessary to check that the atmosphere within a confined space contains sufficient oxygen, is free from both toxic and flammable vapours and is fit to breathe. Testing should be carried out by a competent person using a suitable gas detector which is correctly calibrated. Breathing apparatus should be worn to enter a confined space for testing. Gas testing involves testing the atmosphere at all locations, drain points, instrument bridles, orifices, and at a high and low level, as some denser gases do lie in low positions, e.g. hydrogen sulphide.

Where the risk assessment indicates that conditions may change, or as a further precaution, continuous monitoring of the air may be necessary.

Topic Focus

Atmospheric testing should look for:

- A flammable gas, vapour or mist in excess of 10% of its Lower Explosive Limit (LEL).
- An atmospheric oxygen concentration below 19.5% or above 22%.
- An atmospheric concentration of any substance for which a Workplace Exposure Limit (WEL) is published in EH40 by the HSE and which could result in employee exposure in excess of the permissible limits.
- An airborne combustible dust at a concentration that obscures vision at a distance of 5 feet (1.52 m) or less.
- Any atmospheric condition recognised as immediately dangerous to life or health.

Means of Access

Safe access/egress must be provided. No one may enter or remain in a confined space unless the following requirements are met:

- They are wearing approved breathing apparatus if dangerous fumes are present or in an oxygen-deficient atmosphere. The minimum space required in this case is 575 mm. Smaller openings must be assessed for safe access and egress.
- Depending on the work being done, a number of access and egress points may be required.
- They have been authorised to enter by a responsible person, i.e. through a permit-to-work system.
- Where practicable, they are wearing a belt or harness with a rope securely attached.
- A person keeping watch (sentry) outside and capable of pulling them out is holding the free end of the rope.

A person may enter or work in a confined space without breathing apparatus, provided that:

- Effective steps have been taken to avoid ingress of dangerous fumes.
- Sludge or other deposits liable to give off dangerous fumes have been removed/cleaned.
- The space contains no other material liable to give off such fumes.
- The space has been adequately ventilated and tested for toxic, flammable and explosive gases/fumes.
- There is a supply of breathable air.
- The space has been certified by a responsible person as being safe for entry for a specified period without breathing apparatus.

Personal Protective Equipment

Appropriate PPE needs to be worn which:

- is fit for purpose;
- fits correctly; and
- is compatible with any other equipment worn.

In confined spaces this might include hard hats, coveralls, boots, Wellingtons, breathing apparatus sets, gloves and/or safety spectacles, radios.

Monitoring Arrangements

Monitoring is carried out by competent, trained personnel with individual detector tubes which are available for specific substances.

Gas monitoring can be carried out using appropriately calibrated portable gas detection equipment. The gas meters can be used to detect individual gases or to sample a range of gases.

Personal monitors may also be used by individuals working in confined spaces.

Topic Focus

Monitoring may be required:

- Before the first entry.
- At the start of each shift.
- At each entry.
- After each break.
- At a specified time limit as set out in the permit.
- Continuously.

Emergency Arrangements

The **Confined Spaces Regulations 1997** require arrangements for emergency rescue to be in place when working in a confined space. The rescue plan must be communicated to all personnel involved before commencing work.

- Arrangements for raising the alarm and carrying out rescue operations must be in place.
- Rescue team members and equipment should be readily available for emergencies.
- Team members must be:
  - Properly trained in rescue techniques and use of all equipment.
  - Physically fit enough to carry out their task.
- Rescuers must be aware of and protected against the cause of the emergency.

Rescue equipment should consist of:

- Breathing apparatus sets.
- Rescue and resuscitation equipment, harnesses, lifting tripods and winch, stretchers, first-aid equipment.
- Fire-fighting equipment.
- Means of communication and summoning help:
  - A tug-rope is commonly used when personnel are not visible.
  - If radio is to be used it must immediately be tested on entry.
- Lifelines.
- Oxygen – for resuscitation, not for 'sweetening' (increasing the oxygen content in the atmosphere).

Rescue teams must not enter without breathing apparatus. They must be thoroughly trained in rescue techniques, first-aid and use of resuscitators.

An essential part of such a rescue plan might include:

- Shutting down adjacent plant before attempting emergency rescue.
- Communication with local emergency services (e.g. the Fire Service), remembering to pass on information about the particular dangers in the confined space.

Revision Questions

8. What precautions are necessary for safe entry into a confined space?
9. What factors might be involved in a safe system of work for confined space entry?

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

Summary

This element has introduced you to the hazards and precautions required to ensure safe work at or in excavations and confined spaces.

In particular this element has:

- Described the hazards and risks associated with working in excavations, including falls into excavations, collapse of sides, collapse of adjacent structures, water ingress and contaminated ground.
- Described measures that will adequately control risks, such as marking of buried services and safe digging methods; methods of supporting excavations; means of access and crossing points; barriers, lighting and signs; safe storage of spoil and removal of water; safe routeing and positioning of vehicles; and appropriate PPE.
- Described particular requirements for ensuring safety when working in contaminated ground, and inspection requirements for excavation supports.
- Defined what a confined space is and identified confined spaces found in construction activities.
- Described the hazards and risks associated with confined space working, including toxic, flammable and explosive atmospheres; heat, water and free-flowing solids; and work in restricted space.
- Described the appropriate measures to control the risks, including precautions to ensure safe entry, risk assessment and planning, permit-to-work procedures, training and competence, atmospheric testing and monitoring, means of access, appropriate PPE, and emergency arrangements.

NEBOSH Certificate Unit FC1

Element 4: Fire Protection in Buildings

RRC TRAINING

Contents

Learning Outcomes

On completion of this element, you should be able to demonstrate understanding of the content through the application of knowledge to familiar and unfamiliar situations. In particular you should be able to:

- Outline the means of fire protection and prevention of fire spread within buildings in relation to building construction and design.
- Explain the requirements of a means of escape.
- Outline the methods and systems available to give early warning in case of fire, both for life safety and property protection.
- Outline the selection procedures for basic fire extinguishing methods for both life risk and process risk.
- Explain the requirements for ensuring access for the fire service is provided and maintained.

Hints and Tips

After reading a section of text try to write out a summary of that section using your own words.

Fire Protection and Prevention of Fire Spread Within Buildings

Key Information

- Fire safety requirements concerning structural features of buildings are contained in the **Building Regulations 2000** or **Building (Scotland) Act 2003**.
- The elements of structure are principally the main load-bearing elements of a building and have a significant influence on structural fire safety.
- The main requirements for fire resistance of elements of structure are resistance to collapse, integrity to prevent fire and smoke penetration, insulation to prevent transfer of excessive heat, and effective fire resistance of fire doors.
- Compartmentation inhibits spread of fire within buildings but needs to be supplemented with protection of openings in compartment walls and floors, and fire stopping of any gaps.
- Internal fire growth can be increased by building lining materials, and the fixtures, fittings and contents of the building; each of these elements should be considered individually in an attempt to minimise fire spread.
- External fire spread can be prevented by considering the construction of external walls and roofs, the distance between buildings, and the use or activities undertaken at the particular and surrounding premises.

Building Regulations 2000

Building construction has a major impact on the spread of fire; you will find fire safety requirements relating to structural features in the following building legislation (depending on locality):

- **Building Regulations 2000**.
- **Building Regulations 2000 (Northern Ireland)**.
- **Building (Scotland) Act 2003** (and regulations made under it).

All have broadly similar provisions in relation to fire safety.

The **Building Regulations 2000** apply to new buildings and alterations in England and Wales only, and are supported by a number of Approved Documents which give practical guidance on how to comply with the regulations.

The Building Regulations and Approved Documents complement specific fire legislation which covers:

- General fire precautions - **Regulatory Reform (Fire Safety) Order 2005**.
- Process-related fire precautions - **Dangerous Substances and Explosive Atmospheres Regulations 2002**.

Where fire safety is concerned, the main relevant Approved Document is **Part B** *Fire Safety*, which deals with five major areas:

- Means of warning and escape, e.g. alarms, escape routes.
- Internal fire spread (linings), e.g. wall and ceiling linings.
- Internal fire spread (structure), e.g. compartmentation, fire-stopping.
- External fire spread, e.g. space separation, roof coverings.
- Access and facilities for the fire service, e.g. fire mains, vehicle access.

Approved Document Part M *Access to and Use of Buildings* covers access for the disabled.

BS 9999:2008 *Code of practice for fire safety in the design, management and use of buildings* gives recommendations and guidance on the design, management and use of buildings to achieve acceptable levels of fire safety for all people in and around buildings.

Planning and designing for fire safety

Elements of Structure

Elements of structure are principally the main structural load-bearing elements of a building with the addition of all compartment walls (which may or may not be load-bearing).

Jargon Buster

Elements of structure

Defined in Appendix E to Approved Document B as a(n):

- Member forming part of the structural frame of a building or any other beam or column.
- Load-bearing wall or load-bearing part of a wall.
- Floor.
- Gallery - a floor which is less than one-half of the area of the space into which it projects.
- External wall.
- Compartment wall - a fire-resisting wall (or floor) used to separate one fire compartment from another.

Elements of Structure – Properties for Fire Resistance

In Approved Document B, **fire resistance** is described as *"the ability to resist the effects of fire"*.

For structural elements this includes:

- **Resistance to collapse:**
  - Maintenance of load-bearing capacity of load-bearing elements.
- **Fire and smoke penetration:**
  - Maintenance of element integrity to prevent passage of fire/smoke.
- **Transfer of excessive heat:**
  - Maintenance of insulation properties to prevent conduction of heat.
- **Resistance of fire doors:**
  - The period of time a door can successfully hold back the spread of fire.
  - Shown as a fire rating, e.g. a fire door with a 30 minute rating, which is the most commonly used in the UK, is shown as FD30.

Compartmentation

Compartmentation reduces the rate of fire spread and keeps fires relatively small by subdividing the building into smaller fire-resisting units using fire-resisting walls and floors.

The degree of compartmentation needed depends on factors such as:

- **Building use/fireload**, which determines the likelihood of a fire starting and its severity.
- **Building height** to the floor of the top storey, which affects ease of evacuation and access by the fire brigade.
- Presence of **sprinklers**, which may control and rapidly extinguish a developing fire.

There are situations where compartmentation is necessary:

- A **wall** common to two buildings.
- Parts of a building largely used for **different main purposes**, such as an office over a shop.
- Places of **special fire hazard** (switch rooms, boiler rooms - with enclosure in a fire-resisting structure).
- Storeys with **large floor areas** in non-residential buildings such as offices, shops and industrial premises.
- **High-rise buildings** with storey floors above 30 m above ground level (with each floor as a compartment floor).

Compartments should form a **complete barrier to fire**:

- No **gaps** between walls and floors to allow fire to spread between the compartments.
- Sufficient **fire resistance** of at least 30 minutes and sometimes considerably longer.

Special types of fire compartment construction are termed **protected shafts**, such as stairways and service shafts; walls/floors bounding such features must be made as compartment walls/floors.

Designing and building for fire safety

Openings in Compartmentation and Fire-Stopping

Openings in compartment walls should be limited to:

- Doors - fire resistant, with typically at least 30 minutes integrity.
- Pipes, ventilation ducts, flues, chimneys, appliance ventilation ducts.
- Refuse chutes - non-combustible.
- Atria.
- Protected shafts.

These openings need to be protected where they pass through the fire compartment wall/floor, in order to maintain the fire resistance of the compartment. Measures include:

- For flues:
  - Flue walls are fire-resisting.
- For pipes:
  - Proprietary seal.
  - Fire-stopping around the pipe where it passes through the compartment.
  - Non-combustible sleeving around the pipe, used in conjunction with fire-stopping.

Jargon Buster

Fire-stopping

A seal to stop or restrict the progression of fire/smoke (but may need to allow for thermal expansion if necessary).

Fire-stopping materials include:

- Cement mortar.
- Gypsum-based plaster.
- Glass fibre.
- Ceramic/resin binder mixtures.
- Intumescent mastics (which expand on the application of heat/flame).

Topic Focus

Poor fire stopping leads to:

- Reduction in the level of fire resistance.
- Passage of heat and combustion products through the holes.
- Potential for fire to spread easily between the fire compartments.
- Potential for heat and combustion products to inhibit employees' escape.

Other reasons for reduced effectiveness of compartmentation in a building:

- Poorly maintained or badly fitting fire doors.
- Fire doors wedged open.
- Absence of, or damage to, intumescent seals.
- Absence of, or poorly maintained, shutters in ducting.
- Poorly fitting or damaged ceiling tiles in fire-resisting false ceilings.
- Absence of, or damage to, fire-resistant glazing.
- Absence of, or damage to, cavity barriers.

Concealed spaces/cavities, such as ceiling voids (e.g. above a suspended ceiling), roof/loft cavities and inside stud partition walls are an easy route for smoke/fire. The principal means of control is by use of **cavity barriers** which:

- Divide up a cavity to act as a barrier to progression of the fire.
- Must have at least 30 minutes' fire resistance.
- May contain openings, as described above for fire compartments.

Internal Fire Growth

The speed and significance of internal fire growth can be influenced by building and lining materials and the fixtures, fittings and contents of the building. These should all be considered individually when attempting to minimise fire spread.

Lining Materials

These are used to line partitions, walls, ceilings or other internal structures and should:

- Resist the spread of surface flame.
- Not have an unreasonable rate of fire growth and heat release.

Resistance to surface spread of flame is indicated by a class number, with:

- **0** being the highest rating for brickwork, concrete, ceramic tiles and plasterboard used in most circulating spaces and escape routes, and
- **3** being the lowest rating for timber, plywood, hardboard, glass reinforced polyesters used in small rooms for non-residential accommodation.

Unprotected cellular plastic linings (for walls and ceilings) are a particular fire hazard and have been the subject of alerts issued by the Health and Safety Executive.

Topic Focus

For surface lining materials:

- The risk of fire spread and its growth depend on:
  - Ignitability.
  - Rates of surface flame spread and heat release.
  - Amount of smoke produced.
  - Propensity to produce flaming droplets.
- To minimise the risk from fire, surface lining materials should:
  - Resist ignition.
  - Have a low rate of surface flame spread and heat release limiting the amount of smoke produced and the rate of fire growth.
- Examples of low risk surface lining materials include:
  - Exposed blockwork.
  - Exposed brick work.
  - Mineral fibre board.
  - Woodwool slabs.
  - Plasterboard and skim.
  - Intumescent linings.

Fixtures, Fittings and Contents

Seating, workstations, furniture, floor coverings, curtains and blinds are usually made from carbonaceous material and/or plastics and will therefore contribute to internal fire growth if a fire breaks out unless treated to be flame retardant.

Preventing External Fire Spread

External Walls and Roofs and Distance Between Buildings

As well as being concerned about internal fire growth, fire resistance is also required for external walls and roofs to resist the spread of fire over the building itself and from one building to another.

The likelihood and consequences of fire spread **between buildings** depends on the:

- **Size** and **intensity** of the fire in the building concerned.
- **Distance** between the buildings.
- **Fire protection** given by their facing sides.
- **Risk to people** in the other building(s).

Requirements for **external walls** include:

- **Load-bearing** parts must always be fire-resisting - to maintain resistance to collapse.
- **Parts next to an external escape route** must have 30 minutes' fire resistance - to protect those escaping from fire inside the building.

External walls of **tall buildings** must always be fire resistant - regardless of distance to the boundary.

Non-load bearing external walls may have variable levels of fire resistance depending on the separation distance from the boundary:

- Less than 1 m - fire-resisting from both sides.
- Greater than 1 m - fire resistance on the inside surface.

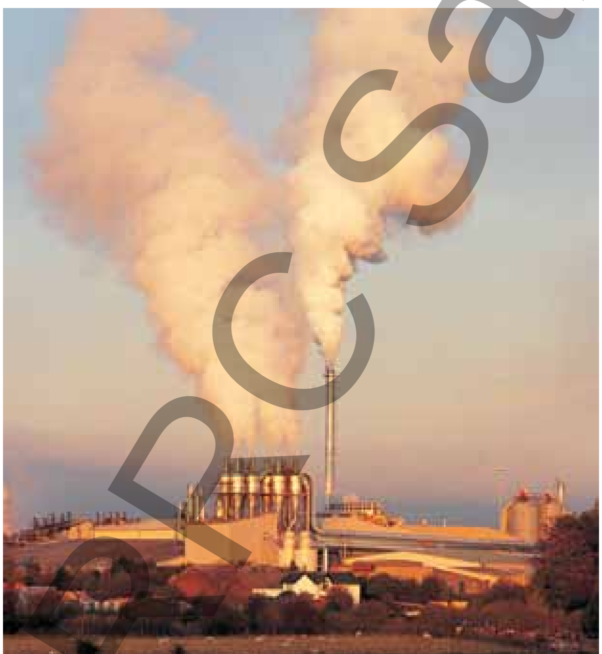
Roof requirements include:

- Steep-angled roofs (more than 70° from the horizontal) are treated as external walls.
- Non-combustible roof coverings (natural slate) have no restrictions.
- Combustible roof coverings (thatch, wood shingles) must be at least 6 m from the boundary.

Use of Premises and Surrounding Premises

The use of the building or the Purpose Group that it falls into affects the degree of fire resistance required to prevent external fire spread. This use classification represents different levels of hazard:

- Premises used for office-type work - **Group 3**.
- Factories and other industrial premises used for manufacturing - **Group 6**.



A building's use affects its Purpose Group classification

Topic Focus

Fire can spread **externally** between buildings by:

- Flame spread.
- Radiated heat.
- Burning brands and embers.
- Effect of wind.

Methods of **minimising** external fire spread between buildings:

- Adequate distance between buildings.
- External walls constructed from material that prevents or reduces the risk of ignition from an external source and limits the surface spread of fire.
- Roof coverings that offer fire protection to increase their resistance to radiated heat and burning embers.
- Limiting the number of openings in adjacent buildings to reduce the amount of thermal radiation that can pass through the wall and affect the neighbouring building.
- Provision of external drenchers to protect nearby buildings from radiated heat.

Revision Questions

1. What is meant by an "element of structure" in relation to buildings?
2. What do you understand by the term "fire resistance" in relation to structural elements?
3. What is "fire-stopping"? What measures might be taken to preserve the fire resistance of a compartment wall where a water pipe passes through it?

(Suggested Answers are at the end of Unit FC1.)

Means of Escape

Key Information

- The means of escape provides an accessible, well lit, signed route, protected from fire and smoke, which allows people to escape to a place of safety outside the building.
- For effective means of escape there should be alternative escape routes, adequate travel distances and an appropriate number and size of escape routes for the number of occupants in the building.
- Other elements of the means of escape include escape stairs, passageways and doors, suitable protection, emergency lighting, escape lighting and signage, design for progressive horizontal evacuation, and provision of a final exit to a place of safety.
- Maintenance, inspection and testing is required to manage the effectiveness of the means of escape.
- Vulnerable people and people with disabilities or mobility problems may need the use of evacuation lifts and refuges, graphic, aural and tactile way-finding and exit sign systems, and also personal emergency evacuation plans (PEEP).

Jargon Buster

Means of escape

"*Structural means whereby [in the event of fire] a safe route or routes is or are provided for persons to travel from any point in a building to a place of safety*". (Approved Document B)

Place of safety

"*A safe area beyond the premises*". (Regulatory Reform (Fire Safety) Order 2005)

A **means of escape**:

- Is part of the **structure** of the building.
- Provides an **accessible, well lit, signed** route.
- Has fire and smoke **removed/restricted** for long enough to allow escape to a **place of safety**:
  - Outside the building.
  - Beyond a final exit.
  - Far enough away from the building so that a person is no longer at significant risk of harm from fire.

Principles of Means of Escape and General Requirements

Approved Document B describes principles for the design of means of escape.

Normally **alternative means of escape** should be provided. However, it is not always possible to get directly to an **ultimate place of safety** (i.e. outside the building through a final exit) within a reasonable time/distance.

In such circumstances, buildings should be designed so that people can get to a **place of relative safety** (e.g. protected stairway, protected corridor, storey exit) on a route to a final exit, within a reasonable distance.

For the first part of the journey the escaping person will initially travel through an unprotected area, and then through a protected area for the remainder.

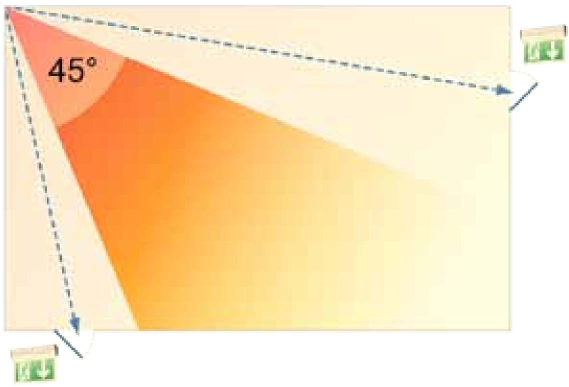
The initial unprotected area should be as short as possible.

Lifts (except evacuation lifts for disabled people), portable ladders, throw-out ladders, fold-down ladders, chutes and the like are not acceptable means of escape.

Alternative Escape Routes

These should be:

- Available so that a person can escape from anywhere in the building, even if the first choice route turns out to be impassable.
- In directions at least 45° apart from any point in the room to prevent blocking by the same fire.



Acceptable Alternative Escape Routes

Dead-end corridors are not normally acceptable.

Maximum Travel Distances

Jargon Buster

Maximum travel distance

"The actual distance to be travelled by a person from any point within the floor area to the nearest storey exit, having regard to the layout of walls, partitions and fittings." (Approved Document B)

Storey exit

"A final exit, or a doorway giving direct access into a protected stairway, firefighting lobby, or external escape route". (Approved Document B)

The **maximum travel distance** depends on the level of fire risk:

- How many escape routes are provided.
- The building use.

The following table gives illustrative examples for **horizontal escape** (i.e. travel within a storey).

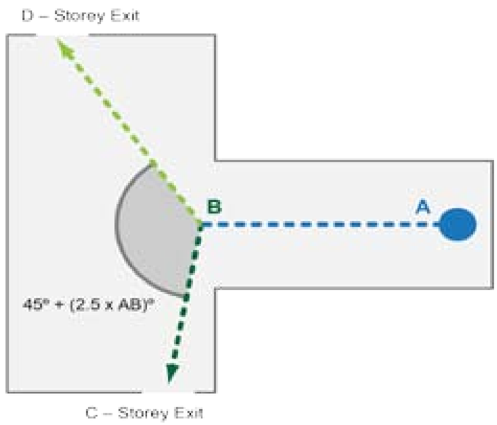
Maximum Travel Distance for Horizontal Escape

Building use	Maximum travel distance to the nearest exit where escape in one direction only provided (m)	Maximum travel distance to the nearest exit where escape in more than one direction provided (m)
Industrial – normal risk	25	45
Industrial – high risk	12	25
Shop and commercial	18	45
Office	18	45

Note: The maximum travel distances are to the **nearest exit**. Any other exits can be further away.

For **dead-ends**:

- The total travel distance to the storey exit (ABC or ABD) should not exceed the guidance figure for "more than one direction".
- The maximum dead-end travel distance (AB) should also not exceed the "one direction only" figure.



"Dead-End" Escape Routes

Number and Size of Escape Routes for Number of Occupants

The greater the number of persons on the premises, the more escape routes are needed.

For **known occupancy**, Approved Document B gives the following guidelines on escape routes/exits:

Number of Escape Routes Per Occupancy

Maximum number of persons	Minimum number of escape routes/exits
60	1
600	2
>600	3

For **unknown occupancy** the number of persons on the premises can be estimated by dividing the floor area by a "floor space factor" discounting stairs, lifts and toilets from the calculation. The floor space factor is simply a figure of roughly how much floor space each person needs in a given area and some examples are given below:

Example Floor Space Factors

Area type	Floor space factor (m^2/person)
Public bars without seating	0.3
Amusement arcade, assembly hall, bingo hall, club	0.5
Factory production area	5.0
Office	6.0
Warehouse	30.0

Example

In an office area of 600 m^2 with a floor space factor of 6.0 m^2/person the estimated capacity would be 600/6.0 = **100 people.**

From the earlier table (**Number of Escape Routes Per Occupancy**) a maximum number of 100 persons would need a minimum number of two escape routes.

Occupancy also determines the **minimum width** required for each escape route and exit:

- 750 mm for up to 50 people.
- 850 mm for up to 110 people.

The minimum width is greater for areas accessible to disabled people.

An existing exit width will therefore determine the **exit capacity** for that route.

For example, **3 exits**, each **850 mm wide**, will give a total exit capacity of **330 people**.

Requirements for Escape Stairs

So far we have looked at horizontal escape. In a multi-storey building, we also need to consider vertical means of escape using escape stairs.

The **number** of escape stairs required depends on:

- The constraints imposed by the requirements for horizontal escape routes to keep within maximum travel distances.
- Whether independent stairs are required in a mixed occupancy building where there are very different use areas with very different fire risks.
- Whether a single stair is acceptable. For example, if independent stairs are not required (see above), basements and small premises which fulfil certain conditions are permitted to have a single stair.
- Provision of adequate width for escape providing for enough total exit capacity.
- Whether the stairs also need to serve as fire-fighting stairs used in larger buildings by the fire brigade.

The **width** of escape stairs depends on:

- The exits which lead to them (of equal width).
- The likely number of people using the stairs in a fire emergency.
- The number of floors served.
- The type of evacuation (phased versus simultaneous).

Also escape stairs should not:

- Be wider than 1400 mm (for stairs with a descent of 30 m or more), unless fitted with a central handrail to ensure full use of the available width.
- Reduce in width at any point on the way to the final exit to create a bottleneck.
- Be less than 1000 mm wide (although some circumstances may allow 800 mm).

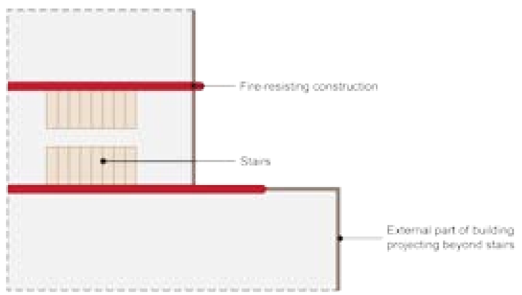
Internal Escape Stairs

So that an adequate level of fire protection for internal escape stairs is achieved there are the following requirements:

- **Enclosure** - internal escape stairs should generally be protected within a fire-resisting enclosure.
- **Protected lobby/protected corridor/smoke control system** – may be necessary as additional protection where:
  - There is only a single stairway serving a multi-storey building.
  - Phased evacuation systems are in operation.
- **Discharge to final exit** – or to a protected exit passageway leading to a final exit.
- **Adjoining (protected) stairways** - need to be separated by an enclosure.
- **Use of space** – kept free of all sources of ignition and fuel.
- **External walls** – may need additional protection as

shown below:

- The stairwell is situated at an "internal corner" of the building façade with part of the building projecting beyond it.
- A fire in the projecting part may make the stairs unusable.
- Fire protection of the side wall of the stairwell should therefore be continued for at least 1800 mm into the external wall of the adjacent projecting façade.



Extended Side Wall Protection of Protected Stairways

- **Gas service pipes** - should not normally be incorporated into a protected stairway.

Basement Escape Stairs

These are more likely to be filled with smoke:

- A stairway forming a single escape route from upper storeys must not continue on down into the basement.
- The basement stairway should be separate (protected lobby/corridor) from the upper storey escape route.

External Escape Stairs

These are allowed provided there is at least one internal escape stair to escape from every part of each storey.

In areas accessible to the public:

- Doors giving access to external escape stairs must be fire-resisting and self-closing.
- The adjacent external wall of the building must be fire-resisting.
- Weather protection must be provided if more than 6 m in vertical height.

Passageways/Corridors and Doors

Passageways, corridors and doors along escape routes should meet the following requirements:

- **Openings** into rooms off escape corridors should be fitted with doors (these do not need to be fire doors).
- **Headroom** should be at least 2 m (though door frames can project below this height).
- **Floor surfaces** (including stair treads) should be chosen to minimise slipperiness when wet.
- **Ramps** should be designed to comply with requirements for access for disabled people.
- **Slopes** should not be greater than 35° to the horizontal.
- **Final exits** should be:
  - At least as wide as the minimum required for the escape routes that lead to them.
  - Sited to aid rapid escape away from the vicinity of the building, e.g. straight onto a street.
- Any **doors** along the escape route should:
  - Be easily opened.
  - Open in the direction of escape and to at least 90°.
  - Be fitted with vision panels.
  - Not be revolving, turnstiles or automatic.

Protection of Escape Routes

Corridors must have fire-resistant walls and self-closing fire doors in the following circumstances:

- Corridors serving a bedroom.
- Most dead-end corridors where escape is in only one direction.
- Most corridors common to two or more different occupancies.

Where an escape route needs to be enclosed by a fire-resistant construction 30 minutes' fire resistance is generally adequate.

Topic Focus

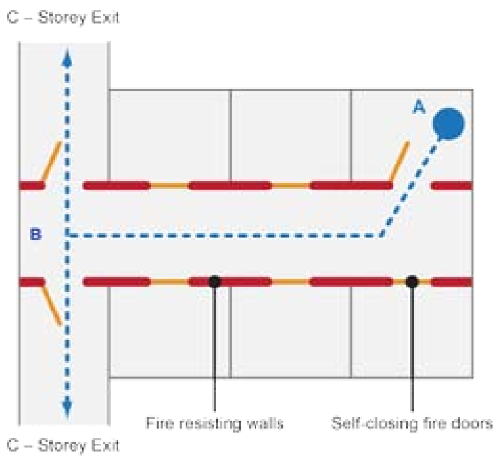
Items that **should not be located** on protected routes:

- Heaters, either portable, gas supplied or with naked flames.
- Cooking appliances.
- Upholstered furniture.
- Coat racks.
- Electrical equipment.
- Lighting using naked flames.
- Gas boilers, pipes or meters.
- Unprotected notice boards and display materials.
- Open shelving with documents.

Fire doors have a minimum fire resistance of 30 minutes' integrity and resist the passage of smoke.

Where a corridor (more than 12 m long) **connects two or more storey exits** it needs to be subdivided by self-closing fire doors to prevent being blocked by smoke.

Similarly **dead-end corridors** must be fire protected. Where the dead-end exceeds 4.5 m in length, it must be separated from the main corridor with **self-closing fire doors** to stop smoke cutting off both alternatives illustrated in the following figure.



Dead-End and Main Corridors

Fire-Resistant Doors

Fire-resistant doors prevent the spread of fire and smoke, protect the means of escape and segregate areas of special risk.

Fire resistance must be complete across the door assembly and all components including door seal and glazing, must be capable of achieving this.

The fire door must be correctly fitted into the corridor or protected stairwell and this requires that the:

- Frame be of the correct size and material, and installed correctly.
- Gaps between the frame and wall are correctly filled.
- Correct intumescent seals are used.
- Vision panels are correctly formed and glazed.
- Correct closer is fitted.

Topic Focus

Features of a **fire-resisting door set**:

- The door is fitted with:
  - Three hinges to maintain integrity.
  - A positive self-closing device.
  - A "keep closed" sign at eye level.
  - Intumescent strips and smoke seals to prevent the passage of combustion products.
- The door provides a good fit for the frame and closes correctly.
- If the door contains a window it is made from Georgian wire or insulated glass.

Fire doors should be regularly **inspected and maintained** to ensure their continued effectiveness, particularly to check that:

- The door closes effectively from any angle of opening using only the door closer.
- There are no foreign bodies or other objects obstructing the door.
- Any smoke seals are correctly fitted and undamaged.
- The door has not dropped on its hinges.
- The door closing arm is effective.
- Glazing is secure and intact.
- Door hold-open devices are working effectively.
- Doors are not wedged open.

Fire doors may not provide the required fire resistance if they:

- Have been incorrectly specified - excessively large gaps around the frame or at the bottom of the door which will allow smoke and fire penetration.
- Are inappropriately used - blocking fire doors open will allow the fire to travel past the fire barrier in which the door is placed.

Topic Focus

A fire-resisting door **may not provide adequate protection** in the event of a fire because:

- The door is wedged open, possibly with a fire extinguisher.
- A gap exists around the door frame due to incorrect specification or poor fitting.
- Smoke seals are damaged or the intumescent strips have been removed.
- Glazing is damaged or has been replaced with glass of inadequate fire resistance.
- The door is warped or does not close properly due to an obstruction or a damaged closure.
- Fire integrity of the door has been reduced following unauthorised and poor alteration work.
- Door hinges have failed through incorrect installation, poor workmanship and lack of maintenance.
- The door has been repeatedly painted with solvent-based paints.

Emergency Escape Lighting

Emergency escape lighting is independent of the main lighting and activated by battery power when the main lighting fails. Batteries are kept on permanent charge under normal conditions and are typically designed to last at least an hour. Lighting supplying escape stairs should be on a separate circuit from any other escape route lighting.

Escape lighting is required in escape routes in workplaces in:

- Underground/windowless areas.
- Internal corridors more than 30 m long.
- Open-plan areas more than 60 m^2.
- Most stairways.

Emergency lighting should:

- Provide enough light to allow people to move along the route.
- Clearly indicate the escape route itself.
- Allow for easy location of fire call points.

Emergency Escape Signage

Signs should clearly indicate the escape routes.

Escape route signs have white pictograms on a green background (**Health and Safety (Safety Signs and Signals) Regulations 1996**) and are placed on doors, exits and escape routes. Text may be used to supplement the signs.

Examples are:

Emergency Escape Signs

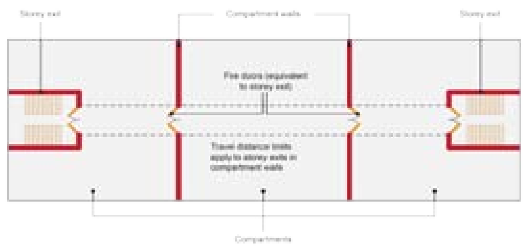
Progressive Horizontal Evacuation

Here evacuation is progressive to adjoining compartments on the same horizontal level and it enables evacuation to a place of relative safety.

It is used in places such as residential care homes and hospitals where it would be difficult to evacuate patients to an ultimate place of safety in one move.

Further evacuation to the ultimate place of safety can take place if it should prove to be necessary.

The following figure shows a suitable design (adapted from Approved Document B).



Progressive Horizontal Evacuation

Final Exit to a Place of Safety

The purpose of the means of escape is:

- To provide an accessible, well lit/signed route where fire/smoke are removed/restricted,
- For long enough to allow escape beyond a final exit,
- To a place outside the building which is sufficiently far away from the building that a person is no longer at significant risk of harm.

How to get to a place of safety

Management Actions to Maintain Means of Escape

To be effective the physical means of escape must be actively maintained to avoid:

- Fire doors left wedged open.
- Corridors and exits blocked with furniture.
- Fire exits left locked/chained.
- Combustibles stored under stairs.
- Failed emergency lighting.
- Damaged wall/ceiling linings.

There are many other examples which might compromise fire integrity.

It is therefore important to have a proactive **maintenance**, **testing** and **inspection** routine as required, such as:

- Weekly/monthly checks of emergency lighting.
- Annual full system checks.
- Regular inspections of escape routes to check such things as:
  - Housekeeping.
  - Unobstructed routes.
  - Proper closing of fire doors.
  - Adequate signage.

Any deficiencies found should be dealt with promptly.

Escape Requirements for Vulnerable People/Those With Disabilities

Jargon Buster

Vulnerable person

Commonly defined as:

- Elderly persons (over 60).
- Children under 10 years of age.
- Mentally or physically impaired persons.
- Those who are mentally ill or depressed.
- Persons on medication.
- Known substance abusers (alcohol or drugs).

Disability

Includes impairment to:

- Hearing.
- Vision.
- Mobility.

Access requirements for disabled people may mean that minimum dimensions given for exits and corridors have to be increased, and extra room may be needed in a corridor to turn a wheelchair into the exit doorway.

Safe evacuation of disabled people requires a combination of building structural design elements as well as procedural measures. Additional measures which may be required to take account of people with disabilities are:

- **Evacuation lifts:**
  - Specifically for the use of disabled people during an emergency.
  - Designed to maintain operation during such an emergency (whereas normal lifts are not).
  - Fitted with an override control inside the car so that a person inside can take control of the lift and take it to the floor from which disabled people need to be evacuated.
- **Refuges:**
  - Fire-protected areas which offer **temporary** relative safety, until full evacuation if it should be necessary.
  - Useful where a disabled person has to wait for help for full evacuation (such as to negotiate stairs) or needs to rest.
  - Generally located on each storey, within an enclosure (e.g. compartment or protected stairwell/lobby/corridor) and close to an evacuation lift.
- **Graphical escape route signage**: supplemented with that specifically designed to help people with disabilities, e.g. "wheelchair" pictogram, clearly indicating the route for disabled people.
- **Tactile emergency exit signs**: with both the words and pictograms in relief and supplemented with Braille text.
- **Continuous handrails/use of strongly contrasting colours**: can help people with visual impairment but who retain some sight.
- **Tactile route maps** and **indications of facilities** (ramps/stairs): help recognition of building layout.
- **Audible way-finding systems**: sound localisation systems.
- **Personal Emergency Evacuation Plans** (PEEP): specific to the individual with the disability who may need:
  - To go to a particular location, such as a refuge or evacuation lift.
  - Particular means of being alerted to a fire, such as visual strobes and trembler alarms/pagers.
  - Help from specific individuals during the evacuation (e.g. buddy systems).

Revision Questions

4. Define a "means of escape".
5. Under what circumstances might you need a protected lobby as additional protection for internal escape stairs?
6. What is meant by "progressive horizontal evacuation" and under what circumstances might it be used?

(Suggested Answers are at the end of Unit FC1.)

Fire Detection and Fire Alarms

Key Information

- Automatic fire detection equipment detects a fire even if the building is unoccupied or the occupants are asleep and usually initiates an alarm system.
- Fire detection is based on sensitivity to temperature rise, smoke or other combustion products, or radiation such as infra-red, visible and ultraviolet.
- Alarm and detection systems are divided into categories which relate to the objective of the system: protection of life, property or manual operation.
- Zoning divides a building into smaller areas and can help speed up the process of locating the seat of a fire in a large building.
- Alarms may be audible or visual, manual or automatic systems, and linked into alarm receiving centres.
- The selection of fire detection and fire alarm systems is based on a number of factors including life risk, process risk, behavioural issues, social behaviour and the need to minimise false alarms, and the requirements for vulnerable people/those with disabilities.
- Fire alarm systems should be routinely serviced at intervals based on the fire risk assessment.

Fire Alarm and Fire Detection Systems

Automatic fire detection equipment usually initiates some form of alarm system since the purpose of detection is to alert occupants to the presence of a fire; the simple "domestic" smoke detector which has an integrated alarm is a good example.

More...

You may find it helpful to refer to the following publications:

- The **Building Regulation Approved Document B** provides general information on the selection of fire detection and alarm systems.
- **BS 5839, Part 1** covers fire detection and alarm system design, installation and maintenance.
- **BS 5839 2004, Part 6** relates to fire resistance in dwellings but differentiates the appropriate grades of fire detection systems for dwellings depending on size, number of storeys and use.

Types of Automatic Fire Detection

Automatic detection systems detect a fire even if the building is unoccupied or the occupants are asleep. Such systems are therefore especially suitable for areas of a building infrequently visited, such as storage areas, and residential properties.

Operation of the detector is based on sensitivity to one or more of the following:

- **Heat** (i.e. temperature or rate of temperature rise).
- **Smoke** or other combustion products.
- **Radiation emitted by the fire** (i.e. electromagnetic radiation such as infra-red, visible and ultraviolet).

Types of equipment available include:

- **Heat Detectors**

  The two main types of automatic heat sensors are:

  – **Fusion** - where particular alloys melt and either break or make a circuit and sound an alarm; the alloys have to be replaced each time the detector operates.

  – **Expansion** - where a contained metal, air or liquid sensor expands to create a circuit and sound the alarm. These sensors usually reset themselves after operation when the conditions have cooled.

  Heat detectors may be designed to operate:

  – At a pre-selected temperature (fixed-temperature

type).
   – On a rapid rise in temperature (rate-of-rise type).

With both types **thermal lag** (the time it takes for the detector to respond to the fire's heating effect) needs to be considered when choosing the operating temperature.

- **Carbon Monoxide Detectors**

  Slow, smouldering fires emit detectable levels of carbon monoxide well before they emit smoke; the gas can be detected by an electrochemical cell.

- **Smoke Detectors**

  There are two types of automatic smoke/fumes detector:

  – **Ionisation devices** - ionise the air in a chamber generating a small current which is reduced when smoke particles enter the device triggering the alarm.
  – **Optical devices** - work in one of two main ways:
    – Smoke **scatters light** from a light source held within a chamber so that it falls onto a photo-electric cell and triggers the alarm.
    – Smoke **obscures** a light beam reducing its intensity at a photo-electric cell and triggers the alarm.

Smoke detector

- **Laser Detectors**

  These are similar in principle to the optical types (see above) except that they use scattering or obscuration of laser beams.

- **Radiation Detectors**

  Flames from a fire emit ultra-violet (UV) and infra-red (IR) radiation which can be detected by appropriate sensors.

  These sensors are capable of very rapid detection but their effectiveness depends on the detector having a clear "view" of all parts of the protected area.

- **Photo-Thermal Detectors**

  These detect both temperature variations as well as smoke density and are far less prone to false alarms than smoke detectors.

Categories of Alarm and Detection Systems

Alarm and detection systems are divided into categories which relate to the objective of the system (BS 5839, Part 1: 2002).

- **Category L (Life Protection)**

  This category covers automatic fire detection systems with the objective of protecting people from loss of life or injury.

  Systems are subdivided into:

  – L1: installed **throughout** the building.
  – L2: installed only in **defined parts** of the building.
  – L3: installed only for the **protection of escape routes**.
  – L4: installed only on **common parts of the escape routes**, e.g. circulation areas such as stairs and corridors.
  – L5: installed to satisfy a **particular fire safety objective** (not already covered in L1 to L4 such as might arise from a fire risk assessment).

- **Category M (Manual Alarm Systems)**

  This category relates to manual systems, which are reliant on people in buildings discovering the fire and using manual "break glass" call points and sounders. Such systems are often combined with categories P and/or L to meet insurance requirements.

- **Category P (Property Protection)**

  These are automatic fire detection systems with the objective of limiting potential fire damage to a building and its contents.

  Systems are subdivided into:

  – P1: installed **throughout** the building.
  – P2: installed only in **defined parts** of the building.

Fire Alarm Zoning

Zoning divides a building up into smaller areas and can help speed up the process of locating the seat of a fire in a large building.

For a simultaneous evacuation alarm no zoning is necessary since everyone needs to be alerted in the same way; the whole building is a single zone.

If alarms need to be operated differently in different parts of the building then zoning requirements are (BS 5839-1):

- Ensure that alarm zone boundaries coincide with:
  - Fire-resisting construction.
  - Detection zone boundaries.
- Eliminate confusion that may be caused by signal overlap between zones.
- Use consistent alarm and alert signals throughout a building.
- Make sure that a detection zone does not contain multiple alarm zones.

Alarm Signalling

Alarms may be:

- Audible, e.g. sirens, bells, verbal instructions over a public address-type system.
- Visual, e.g. strobes, used if ambient noise level is very high or as a supplementary measure for those with a hearing impairment.

Verbal message alarms can be used to give very specific instructions and are effective in generating a rapid response when members of the public are involved.

The most common alarm signal is the **electric bell** or sounder, automatically activated when a fire is detected.

Essential requirements are that:

- The alarm should be capable of being heard throughout the workplace:
  - Enough alarms to take account of possible system faults.
  - Alarms must be loud enough:
    - Generally at least 65 dB (or 5 dB above ambient).
    - Higher noise levels are required to wake a sleeping person (75 dB).
- All signals should be the same or similar throughout the building to avoid confusion.
- Alarms/signals requiring mains power to have a backup power supply in case power is cut off during the fire.

Alarms must be loud enough to be heard

Alarm Receiving Centres

Alarm receiving centres (ARC) receive a message when a fire alarm is activated and call out the fire brigade. The advantage is that no on-site presence is required and even if the site is unoccupied the fire service is quickly alerted.

Manual and Automatic Systems

Manually-operated devices, such as gongs or bells, may be adequate for very small or low risk establishments.

Manually-activated alarms with a "break glass" call point are common in larger workplaces. Manual call points should be located:

- On escape routes near exits.
- Near specific hazards such as flammable liquid stores.
- Within 45 m of building occupants (or less, depending on factors such as occupant mobility).

Manual systems are often supplemented with automatic systems, depending on the nature of the risk, to ensure that the alarm is raised regardless of whether the building is occupied.

Selection of Fire Detection and Fire Alarm Systems

Selection of an appropriate fire detection and alarm system depends generally on the level of risk. The following factors need to be considered:

- **Life risk and process risk** - the objective of the detection and alarm system will determine to a large extent the system design:
  - If the objective is to protect life a Category L design will be appropriate (e.g. hospitals).
  - If process/building is important for business continuity reasons, a Category P system should be installed (e.g. arson may be a big risk).

  The level (L1 – L5, P1 – P2) will be decided by the outcome of the fire risk assessment.

Note that automatic fire detection is **essential** in sleeping accommodation or care facilities.

- **Behavioural issues and social behaviour** - the public react more quickly to clear, precise verbal messages rather than to bells/sirens. A "staff" evacuation system may be required, where staff are alerted first by separate alarms/pagers or a coded message so that they can get to pre-arranged positions and then help the public when the general alarm is sounded.
- **Minimising false alarms** - false alarms in a workplace condition people into thinking that every alarm will be false, which delays evacuation when there is a real emergency.

  False alarms occur due to:

  - Fire detection equipment activated through fault or accident.
  - Intentional hoax calls.
  - Mistaken belief that there is a genuine fire when there's not.

  Key factors in **reducing** the number of false alarms include:

  - Detector type/location - not all detectors are suitable for every location.
  - Measures to prevent stray signals which might cause unintentional activation.
  - Proper commissioning before systems are brought fully online to identify potential faults.
  - Incorporation of false alarm filtering systems:
    - "Voting" systems (i.e. at least two detections from three detectors).
    - Time delays (check the genuineness of an alarm before calling the fire service).
  - Routine maintenance/servicing.

  A common cause of false alarms is the incorrect selection or location of fire detectors. The following summarises the key issues.

Appropriate Use of Fire Detectors

Detector type	**Comments**
Smoke detector	**Optical type** • Good at detecting dense smoke from slower smouldering fires. • Not sensitive to low levels of "invisible" smoke. • Less prone to false alarms than the ionisation type. • Recommended for escape routes. **Ionisation type** • Very sensitive to smoke containing small particles from more rapidly developing fires. • Prone to false alarms from steam or dust. **General** • Not to be used in kitchens. • Unsuitable in: – Rooms where toasters are used. – Locations close to kitchens. – Rooms in which people smoke. – Bathrooms and other rooms which are likely to contain steam. – Areas with high concentrations of dust or engine exhaust fumes. – Areas close to windows that open.
Photo-thermal detector	• Use in areas which would be unsuitable for smoke detectors (less prone to false alarms).
Radiation detectors (IR, UV)	• Useful for: – High-roofed buildings (e.g. warehouses). – Areas where clean-burning fuels kept (so little smoke produced). • Laser beam IR detectors are useful in tall compartments or long cable tunnels.
Carbon monoxide fire detectors	• Very useful for rapid detection where slow, smouldering fires are likely and where little or no smoke may be produced.
Heat detectors	**General** • Good in areas where: – Smoke/steam/dust are present under normal conditions. – Fires would burn with little or no smoke. • The **rate-of-rise type** is the most sensitive. • **Fixed temperature types** are good for areas where there might be frequent rapid temperature swings (kichens, boiler rooms).

- **Requirements for vulnerable people/people with disabilities:**
  - Manual call points sited at a position that wheelchair users can reach - mounting heights and maximum distances to travel to reach the nearest call point need to be lowered for routes accessible to disabled people.
  - The need for trembler and visual alarms would be included in Personal Emergency Evacuation Plans (PEEP).

Maintenance and Testing of Fire Alarm Systems

Fire alarm systems should be routinely serviced at intervals based on the fire risk assessment. This interval should not exceed six months (BS 5839-1) with simpler checks conducted more frequently:

- **Daily** - check the control panel for any fault indications.
- **Weekly** - conduct a planned test by operating a different manual call point each week, checking that:
  - Personnel are familiar with the sound of the alarm.
  - Alarms can be heard (or seen, if visual) throughout the building.
  - Message-type alarms can be understood.
- **Periodic/routine inspection** – carried out every six months to include:
  - **Visual** checks of the equipment.
  - Check logs for **false alarms**.
  - Test operation of **backup power supply**.
  - Check controls/indicators/remote signalling **equipment**.
  - Test for **correct operation** of all call points and fire detectors (this may be scheduled over several visits).

Regular checks of all aspects of the alarm system are essential

Revision Questions

7. Outline the general modes of operation of fire detection systems.
8. Outline the advantages and disadvantages of the different types of smoke detector.
9. How might false alarms occur in the workplace and how might they be reduced?

(Suggested Answers are at the end of Unit FC1.)

Selection of Basic Fire Extinguishing Methods

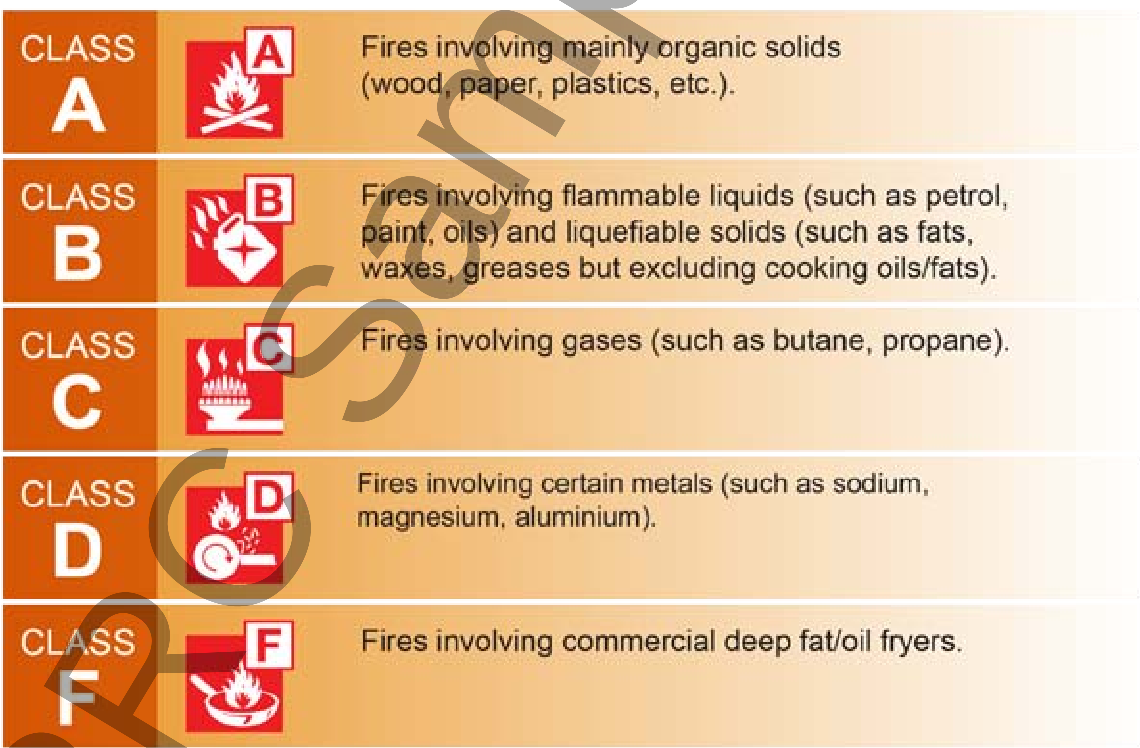
Key Information

- Fire extinguishers use water, foam, dry powders, special powders and carbon dioxide as extinguishing agents.
- The provision of portable fire-fighting equipment and fixed installations depends on the classification of fire anticipated, and the floor area and fire loading of the premises to be protected.
- Portable fire-fighting equipment should be sited in appropriate locations, regularly maintained and likely users trained in its operation.
- Fixed installations such as sprinkler, gas flooding and drencher systems and hose reels provide a permanent means of extinguishing fires in high risk installations.

Provision of Portable Fire-Fighting Equipment and Fixed Installations

Fires are conveniently classified into the following categories to help in the selection of the appropriate extinguishing agent.

Classification of Fires



Electricity is not considered a separate class since, once isolated, the fire can be treated according to the burning materials (typically Class A). However, water and some foam fire extinguishers should never be used on live, electrical equipment due to the fact that electricity may be conducted from the fire, through water to the fire-fighter's body resulting in electric shock.

Extinguishing Media and Mode of Action

The mode of operation of extinguishing media is principally based on the fire triangle:

- **Cooling** (to remove heat).
- **Smothering** (to exclude oxygen).

Some extinguishing media work at a more fundamental level by inhibiting the combustion reaction mechanism.

The Fire Triangle

The main **extinguishing agents** are:

- **Water**
  - The most effective extinguishing agent for Class A fires.
  - It principally cools the material.
  - Small jet restricts coverage.
  - Spray types have a reduced throw.
  - Not to be used on electrical equipment or flammable liquids.
- **Foam**
  - Particularly good for Class B fires and some can also be used on Class A fires.
  - It forms a layer on top of the burning liquid, preventing oxygen reaching it and the further escape of vapour.
- **Dry powders**
  - Effective on fire Classes A, B and C.
  - Can also be used on live electrical equipment.
  - Have a smothering effect on the fire and also chemically inhibit the combustion mechanism.
  - Risk of re-ignition because they offer little or no cooling.
  - Very messy to use even on a small fire.
  - Can disorientate and obscure vision.
  - Powder may affect some people medically, e.g. asthma sufferers.
- **Special powders**
  - Developed for use on Class D (metal) fires.
  - May have to be shovelled onto fires as they may be used on bulk storage.
  - Operators need to be properly trained.
- **Carbon dioxide (CO_2)**
  - Very good for use on live electrical equipment (the gas can get right inside the equipment).
  - Also works on smaller Class B fires.
  - Smothers by displacing the oxygen.
  - Risk of re-ignition because little or no cooling.
  - Oxygen is depleted in the immediate discharge vicinity so there is a danger of asphyxiation if used in relatively confined spaces.
  - May be ineffective if used externally because the gas dissipates quickly and re-ignition can easily recur.
  - Discharge of the gas can be very noisy and may alarm users.
  - The discharge horn can get very cold.
  - The gas may be ineffective if the user can't get close enough to the fire.
- **Wet chemical**
  - Uses an alkaline liquid solution which reacts with the hot fat/oil to produce a soapy layer which traps vapours, excludes oxygen and provides some cooling.
  - Used on Class F fires.
- **Fire blankets**
  - Used on fat or solvent fires.
  - Smother the flames and exclude oxygen.
  - Risk of re-ignition because little or no cooling.
  - Siting is critical as they need to be readily available.
  - Operator training is important in the technique required to place the blanket safely onto the fire.
- **Class C (flammable gas) fires**
  - Extinguished by isolating the supply (e.g. closing the supply valve) so removing the fuel.
  - Usually left to burn until the supply can be isolated.

Portable Fire-Fighting Equipment

Portable fire extinguishers are made up of the following main parts:

- Container (some form of cylinder).
- Extinguishing medium, e.g. water.
- Discharge/operating valve.
- Hose (or horn) for directing the discharge.
- Some form of pressurisation system to propel the extinguishing medium out of the cylinder:
  - Stored pressure (i.e. kept under constant pressure).
  - Pressurising cartridge (which, when punctured, releases a gas which pressurises the cylinder).

Pressure gauge on cylinder

The cylinder body is coloured **red** but the UK also uses an additional **colour-coded label**, depending on the contents:

- Water (red).
- Foam (cream).
- Carbon dioxide (black).
- Dry powder (blue).
- Wet chemical (yellow).

Topic Focus

Points to consider when **positioning** portable fire extinguishers:

- Place in conspicuous positions, clearly indicated, along escape routes and near exit doors.
- Where possible group with other extinguishers into a "fire point".
- Mount properly with the top around 1 m off the ground, or stand on a base plate.
- Locate special extinguishers, such as for Class D metal fires, close to their respective risk.
- Site extinguishers in multi-storey occupancies at a similar location on each floor.
- Avoid placing them in locations where there are extremes of temperature or corrosive environments.

When deciding **how many** extinguishers are needed, there is a system of extinguisher ratings which describe the ability of the extinguisher to do its job. This can be used along with floor area or likely spillage of flammable liquid to determine the number of extinguishers required.

The **maintenance requirements** for portable fire extinguishers involve a system of checks:

- **Monthly visual inspection** to ensure the extinguisher:
  - Is still where it is supposed to be.
  - Access is not obstructed.
  - Has not been discharged, lost pressure or suffered damage.
- **Basic annual service** carried out by a competent person to include:
  - An internal check of the extinguisher contents, any internal corrosion, the means of pressurisation.
  - Checks on hoses for blockages and on the working of any internal mechanisms.
- **Extended service or overhaul:**
  - Testing the intended operation of the extinguisher by discharging the contents, generally every 5 years (10 years for primary sealed powder type).
  - For carbon dioxide extinguishers an overhaul every 10 years to test discharge and also a pressure test of the extinguisher body.

It is generally recommended that fire extinguishers should be replaced when they are 20 years old.

Portable extinguishers are not designed to be used on anything other than very small fires but people still need to be trained in how to use them. Training should cover:

- The principles of how to operate an extinguisher.
- The importance of using the correct type of extinguisher for the correct class of fire.
- How to discharge different types of extinguisher.
- Recognition that raising the alarm takes precedence over fighting a fire.
- When and when not to tackle a fire (the importance of size).
- When to leave a fire that has not been extinguished.

Fixed Installations

Fixed systems are permanent design fixtures of a building, may be automatic or manual, and are made up of a system of pipes together with discharge heads at fixed points in the workplace. They tend to be installed in high risk situations.

- **Sprinklers** have independent, sealed discharge heads and only the sprinkler(s) in the vicinity of the fire is/are actually activated. Water and also foam sprinkler systems are in common use.
  - In **wet riser** systems the pipes are permanently charged with water in a state of constant readiness.
  - In **dry riser systems** the pipes above the main control valve are filled with compressed air which holds back the pressurised water below until a sprinkler head is activated and the water flows. These systems are used where frost damage is likely, such as in cold stores.

  Both types are connected to the mains water supply and use sprinkler heads which are activated by the presence of fire (e.g. fusible link).
- **Gas flooding systems** make the atmosphere inert by the displacement of oxygen with inert gas such as carbon dioxide. Such systems may be used where water or foam might otherwise damage sensitive equipment or valuable archives.
- **Drencher systems** provide a curtain of water to protect parts of a building from the radiant heat of a nearby fire.
- **Hose reels** are permanently connected to a water supply and are used in addition to portable water fire extinguishers. The valve controlling the water supply may be opened automatically as the hose is unwound and the flow rate can be adjusted using a separate valve on the outlet nozzle. Hose reels:
  - Should be conspicuous and accessible, and placed in recessed locations where possible to avoid obstruction.
  - Use water and can only be used on Class A fires.
  - Are limited by the length of the hose together with the discharge range.
  - Can be heavy to pull and move and, when fully unwound, may present an obstacle for fire door closure and for people to trip over.
  - Should be subject to:
    - Regular monthly visual checks (hose condition, damage, leaks, valve operation).
    - An annual check (fully unwound to check the condition of the hose, flow rate, operation of nozzle valve and for leaks).

Hints and Tips

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

Revision Question

10. (a) What are the main factors you should consider when siting fire extinguishers?

    (b) Describe suitable arrangements for the maintenance and inspection of fire extinguishers in the workplace.

(Suggested Answers are at the end of Unit FC1.)

Access for the Fire Service

Key Information

- Fire engines need to be able to get close to the perimeter of a building to be able to use high reach equipment.
- Requirements for access and facilities for the fire service are contained in the **Building Regulations** and there is a duty placed on the Responsible Person by the **Regulatory Reform (Fire Safety) Order** to ensure that they are adequately maintained.
- For high-rise buildings a protected "fireman's shaft" may be needed with provision of a fire mains water supply.
- Basements present a high risk to fire fighters and require smoke and heat venting.
- A nominated and competent person should be designated to liaise with the fire authority on arrival and provide information on the contents of the building and any hazardous materials or processes and facilities.

Fire-Fighting Vehicle Access

Fire engines need to be able to get close to the perimeter of a building so that they can use high reach equipment such as turntable ladders, hydraulic platforms and pump appliances with fire hoses.

The requirements for vehicle access differ depending on the presence of **fire mains**, **building size** and the **type of fire-fighting appliance**.

- For **small buildings** without a fire main, access for a pump appliance should be provided to 15% of the perimeter or to within 45 m of every point on the building surrounds.
- For **large, high rise buildings**, the entire perimeter will need to be accessible to fire-fighting appliances.

The fire service need access to buildings

Jargon Buster

Fire main

A water supply pipe installed specifically for fire-fighting purposes within a building.

The term "rising" fire main (or "riser") is used where it serves floors above ground level.

(Note that fire mains are of two basic types:

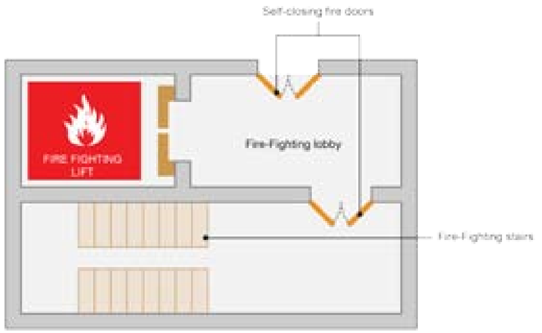
- **Dry fire mains** do not normally contain water; they consist of the fire main together with inlet connections at vehicle access level to enable charging with water from fire service pumping appliances. They then have "landing" valves (a combined outlet and valve) at specific points for connection with fire-fighting hoses. These outlets are situated in each fire-fighting lobby of the fire-fighting shaft.
- **Wet fire mains** are permanently charged with pressurised water; they, too, have landing valves at specific points. They may also be fitted with inlets for emergency replenishment of a wet system.)

In general, where dry fire mains are fitted, pumping appliances should be able to approach to within 18 m of each inlet connection point. For wet fire mains, the appliance should be able to approach within 18 m of an entrance giving access to the main.

Overhead obstructions on the access route should be avoided and turning facilities are also needed where the route includes a long dead-end and would otherwise require excessive reversing distances.

Access to Buildings for Fire-Fighting Personnel

For high-rise buildings a protected fireman's shaft may be needed which combines facilities such as a fire-fighting lift, fire-fighting stairs and fire-fighting lobbies. The number of fire-fighting shafts required depends on the building use, size and design and the presence of automatic sprinklers throughout the building. You can see a diagram of the main components of fire-fighting shafts in the following figure (based on that shown in Approved Document B).



Main Components of Fire-Fighting Shafts

Fire main outlets should be situated within each fire-fighting lobby but the fire-fighting lift is only required where floors are situated more than 18 m above or 10 m below the vehicle access level.

Fire Mains/Water Source

Buildings with a fire-fighting shaft need fire mains installed in the shaft with the outlets accessible in each fire-fighting lobby.

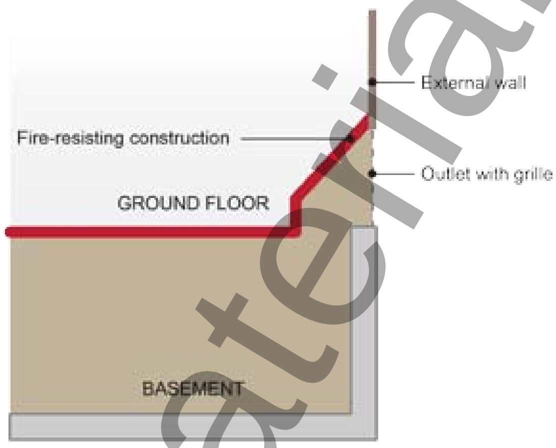
Wet systems are required where storey floors are >60 m above the vehicle access level, otherwise either wet or dry systems are acceptable.

Venting of Smoke/Heat from Basements

Fighting fires in basements is different from ground level and above because heat and smoke rise and fire-fighters have to descend through it. **Smoke vents or outlets** should be installed in every reasonably sized basement space in areas where the external walls don't have windows or doors.

Natural smoke outlets relying on convection currents can be set at ceiling level in basement compartments, on the perimeter, so that they can discharge directly into the open air above. An example is shown in the next figure (modified from that shown in Approved Document B).

The outlet ducts need to be fire-resisting.



Smoke Outlets in a Basement

Mechanical smoke extraction is an alternative to natural ventilation but is only permitted if the basement is protected with a sprinkler system.

Liaison with the Fire Authority

The organisation's Emergency Plan should include arrangements for nominated and competent persons to liaise with the fire service on their arrival.

This is likely to involve designation of the senior person on duty at the scene of any incident involving a fire as a **Nominated Officer**, with duties such as:

- Providing practical assistance to the fire service and any other of the emergency services when they are in attendance.
- Taking overall control of the scene in a fire situation in conjunction with the fire service.
- Co-ordinating and directing staff actions.
- Liaising with fire service officers.
- Making sure that the chief fire officer is satisfied that there is no danger before allowing re-entry to the building.

Contents of Building

In the event of a fire emergency the fire and rescue service need to have information relating to the contents of the building and any hazardous materials or processes and facilities that might create a risk to fire-fighters carrying out their duties.

A **risk assessment** will identify the individual features of a building and the activities carried on there that could present a fire risk. This information can be presented on premises plans marked up with relevant information and made available to the fire service on arrival. This information will be specific to the nature of the building and the activities carried out within it but would need to include details relating to matters such as the presence of:

- **Hazardous materials** – flammable, explosive, oxidising, reactive, toxic, corrosive, pathogenic, radioactive.
- **Hazardous facilities** - X-ray, high pressure, high voltage, dangerous machinery, lasers, microbiological.

The fire service must be aware of anything that would be hazardous in the event of a fire

Revision Questions

11. Explain what is meant by a "fire main" and describe the two main types.

12. Outline the duties of a Nominated Officer for a fire or emergency incident.

(Suggested Answers are at the end of Unit FC1.)

Summary

This element has dealt with fire protection in buildings.

In particular this element has:

- Considered the fire safety requirements concerning structural features of buildings and the main requirements for fire resistance of elements of structure.
- Examined the need for compartmentation to inhibit the spread of fire within buildings.
- Discussed how internal fire growth can be propagated by building lining materials, fixtures, fittings and the contents of a building.
- Examined the means of preventing external fire spread by considering the construction of external walls and roofs, the distance between buildings, and the use or activities carried out at the particular premises.
- Explained the requirements of a means of escape including alternative escape routes, maximum travel distances, and the number and size of escape routes for the number of occupants.
- Examined the requirements for escape stairs, passageways and doors, protection of escape routes, emergency lighting, escape lighting and signage.
- Considered the management actions required to maintain means of escape.
- Identified the requirements for means of escape for vulnerable people and people with disabilities and/or mobility problems.
- Discussed fire alarm and fire detection systems that are available to give early warning in case of fire, both for life safety and property protection.
- Examined fire alarm zoning, alarm signalling and the use of alarm receiving centres.
- Considered the factors involved in the selection of fire detection and fire alarm systems.
- Explained the requirements for maintenance and testing of fire alarm systems.
- Considered the factors involved in the provision, design and application of portable fire-fighting equipment and fixed installations.
- Explained the relevance of the classification of fires when choosing fire-fighting equipment and the range of available extinguishing media.
- Examined the requirements relating to fixed installations (such as sprinkler, gas flooding and drencher systems and hose reels).
- Considered the requirements for ensuring that access for the fire service is provided and maintained.

Question

Explain the requirements for ensuring that access to premises and facilities for the fire service are provided and maintained. (8)

Approaching the Question

Think now about the steps you would take to answer the question:

1. The first step is to read the question carefully. Note that this question asks about access to premises; it is not specific about the type of premise, so you need to provide a range of factors.
2. Next, consider the marks available. In this question there are eight marks so it is expected that around eight or nine different pieces of information will be provided. The question should take around eight minutes to answer in an exam. Statistically candidates score most marks in the first few sentences of their answer; they may then spend several minutes on long rambling explanations that may score the extra few remaining marks available but may cause them to run out of time and leave some questions unanswered. You are unlikely to get many extra marks for long rambling answers. Also remember that for any questions not attempted you get nothing.
3. Now highlight the key words. In this case they might look like this:

   Explain the requirements for ensuring that access to premises and facilities for the fire service are provided and maintained. (8)
4. Read the question again to make sure you understand it asks a two-pronged question about access to premises AND facilities, and then asks another two-pronged question about provision AND maintenance. (Reread your notes if you need to.)
5. The next stage is to develop a plan – there are various ways to do this. Remind yourself first of all that you need to be thinking about 'access' that is provided and maintained to facilities and premises. When you see the action verb 'explain' you need to give a clear account. Your answer plan will therefore need to have more detail added to it to produce a full answer for the examiners.

   Your answer must be based on the key words you have highlighted, so in this case you need to explain access to premises and facilities and their provision and maintenance.

Now have a go at the question. Draw up an answer plan, and then use it as the basis to write out an answer as you would in the exam.

Key hint: think about a range of premises (high rise, shopping centre, high street, etc.).

Remember, you can always contact your tutor if you have any queries or need any further guidance on how to answer this question.

When you have finished, compare your plan and full answer with those that follow.

20

Suggested Answer

Plan

Access to premises and facilities	Provision and maintenance
• Roadways clear. • Access and parking for fire appliance. • Turning circles. • Persons at the premises to assist. • Plans of premises showing facility location. • No storage in front of facilities. • Signage above facilities. • Facilities maintained in good working order. • Building Regulations.	• Ventilation from basements. • Fire-fighter lifts/shafts. • Dry/wet risers. • Adequate water supply. • Adequate supply of specialist equipment if required. • RRFSO, Article 38: maintained in efficient state/ order and good repair.

Possible Answer by Exam Candidate

Access to the premises must be in accordance with Building Regulations and be maintained for fire tenders to attend an emergency; this means that roadways must not be blocked (either by parked cars or vehicles being unloaded) and that provision should be available for turning circles to avoid the need for reversing. Fire tenders must be able to park sufficiently close to hydrants to enable the shortest possible connections. Access to such locations should be cross hatched to prevent unauthorised use. On attending a premises a key holder should be available to provide access, and plans of the premises should be available with facilities, access and egress routes marked on them. Inside premises access to facilities should be unrestricted, so the responsible person for the premises must ensure that items are not stored in front of facilities and that facilities are maintained in an efficient state, efficient working order and in good repair as required by the Regulatory Reform (Fire Safety) Order. Facilities should also have suitable signage near them so that fire fighters can easily locate them. The facilities that may be provided include ventilation from basements or other areas where fumes may accumulate. High rise buildings may have a fire-fighters' lift or shaft to enable easy access to upper storey levels. Dry risers (water supply connected by attending fire fighters) or wet risers (already charged with water) should be available. The water supply to the premises should be adequate to enable the fighting of fires. If the premises is involved in special risk operations (i.e. a metals factory) then a suitable supply of specialist fire-fighting equipment may need to be provided.

Reasons for Poor Marks Achieved by Candidates in Exam

- Providing more of a list without giving sufficient detail to meet the action verb criteria of 'explain'.
- Taking a narrow view of 'provided' and not mentioning fire-fighters' lifts in tall buildings or dry and wet risers.
- If the examiner cannot read the student's answer marks cannot be awarded.

NEBOSH Certificate Unit IGC2

Element 3: Work Equipment Hazards and Control

Contents

Learning Outcomes

On completion of this element, you should be able to demonstrate understanding of the content through the application of knowledge to familiar and unfamiliar situations. In particular you should be able to:

- Outline general principles for selection, use and maintenance of work equipment.
- Outline the hazards and controls for hand tools.
- Describe the main mechanical and non-mechanical hazards of machinery.
- Describe the main methods of protection from machinery hazards.

Hints and Tips

You may find it useful to use the Contents page as a checklist to keep track of which topics you have studied – you could even develop a coding system, e.g. one tick after your first-read through; two ticks after you have completed all the revision questions and are happy that you understand the key points.

General Principles for Selection, Use and Maintenance of Work Equipment

Key Information

- Work equipment should be suitable for the task it is being used for and the environment it is used in.
- It is often necessary to restrict the use of work equipment to competent operators only.
- Information, instruction and training should be provided for equipment users, managers and maintenance staff.
- Work equipment should be maintained in safe working order and maintenance activities carried out safely. Routine inspection of equipment is sometimes necessary to ensure its safe condition. Pressure systems require periodic examination and testing.
- Equipment controls should be clearly labelled and accessible; this is particularly important for stop controls and emergency stops.
- Work equipment should be stable, adequately marked with appropriate warning signs and devices, and environmental factors such as lighting and space should be managed.
- Operators must obey rules for safe use.

There are some general safety principles that can be applied to all items of work equipment, irrespective of type.

Types of Work Equipment

Note that in this element we will use the phrase "work equipment" in a very wide sense to include:

- Simple hand tools, e.g. a hammer, screwdriver or chisel.
- Hand-held power tools, e.g a portable electric drill or circular saw.
- Single machines, e.g. a bench mounted abrasive wheel, photocopier, lathe or compactor.
- Machine assemblies, where several machines are linked together to form a more complex plant, such as a bottling plant.
- Mobile work equipment, e.g. a tractor or mobile crane.

Suitability

All items of work equipment should be suitable for the:

- **Task** it is going to be used to perform, e.g. a chisel is not appropriate for prising lids off tins.
- **Environment** in which it is to be used, e.g. a standard halogen spotlight is not suitable for use in a flammable atmosphere.

Equipment must be carefully selected to ensure that it is suitable for the task and environment on the basis of manufacturers' information.

In many regions of the world there are regulations that require manufacturers to ensure that the equipment that they produce meets basic safety standards. For example, in the European Union a set of safety standards exists that manufacturers are legally obliged to meet; manufacturers are required to fix a "CE" mark to the equipment and provide a written "Declaration of Conformity" to the purchaser.

CE Mark

Employers in the European Union have to ensure that any equipment they purchase for work use has this CE mark and written declaration.

Restricting Use

Use of work equipment should, where necessary, be restricted to competent operators only. This relates to all equipment where risk of serious injury to the operator or to others exists (e.g. a metal-working lathe). Repair, modification or maintenance of equipment should be restricted to designated competent people.

Information, Instruction and Training

Work equipment users should be provided with appropriate information, instruction and training:

- Where the equipment is **low risk**, this requirement is simple to fulfil. For example, an office paper shredder can be used by staff who have read the instructions supplied by the manufacturer.
- With **high risk** machinery more has to be done to fulfil this requirement to an acceptable standard. For example, an employer operating an industrial shredder capable of shredding wooden pallets should ensure that all operators receive specific training in the safe use of the equipment as well as written information. They should also check to ensure understanding of that training and information.

Those involved in the **management of operators** should be given adequate information, instruction and training to allow them to effectively manage. As a minimum they should understand the basic principles of safe use of the equipment.

Maintenance staff should be given specific information, instruction and training so that they:

- Can undertake any maintenance activities with a minimum of risk to themselves and others.
- Understand the maintenance requirements of the equipment and are able to keep the equipment in safe working order.

Maintenance, Inspection and Testing

Work equipment should be maintained in a safe working condition, according to any legal standards that exist and manufacturers' recommendations.

Engineer carrying out condition-based maintenance

Maintenance can be carried out according to various regimes, such as:

- **Planned preventative maintenance (PPM)** – where servicing work is carried out at prescribed intervals and parts are replaced or changed irrespective of their condition. For example, oil in an engine might be changed every year regardless of the amount of use that the engine has received.
- **Condition-based maintenance** – where servicing is carried out and parts changed only where inspection indicates that use has caused deterioration. For example, the brake pads on a car might be inspected every 10,000 km but only changed when they show signs of heavy wear.
- **Breakdown maintenance** – where maintenance is only carried out during repair.

Whatever type of maintenance regime is used for an item of work equipment, maintenance staff must not be exposed to unacceptable risk during maintenance work.

Maintenance work often creates greater risk for the staff involved because:

- Guards and enclosures have to be removed to allow access.
- Safety devices have to be removed or disabled.
- Equipment has to be partially or completely dismantled.
- Power sources may be exposed (e.g. electrical supply).
- Stored power may be accidentally released (e.g. compressed spring).
- Access may be awkward (e.g. space constraints or work at height).
- Handling of parts may be difficult (e.g. heavy parts).
- Additional hazards may be introduced (e.g. power tools).

Topic Focus

Additional precautions may be required during maintenance work:

- Maintenance should only be carried out by competent staff.
- Power sources should be isolated and physically locked off (secured).
- Stored power should be released or secured to prevent accidental discharge.
- Where power cannot be isolated additional precautions required are:
  - Cover live parts with insulating material.
  - Use additional PPE such as insulating rubber gloves.
- If dangerous moving parts have to be accessed additional precautions required are:
  - Run at very slow speed rather than normal operating speed.
  - Fit maintenance guards that have been made specifically to allow minimum access to required areas only.
- Precautions should be taken to allow safe access, especially when working at height.
- Handling aids and equipment should be used to reduce manual handling risk.

A safe system of work should be developed for when maintenance work is carried out and this may require the use of a permit-to-work and adequate levels of supervision (remember your Unit IGC1 studies).

For some items of work equipment it is foreseeable that deterioration of safety critical parts might occur and it is possible for these parts to be inspected without dismantling the equipment. It may be necessary to introduce some form of inspection regime. For example, the tyres on a vehicle might go flat or become excessively worn and it is an easy matter for the driver of the vehicle to carry out a pre-use inspection to check their condition.

In certain instances this routine inspection should be combined with a more detailed periodic examination and testing. Pressure systems, such as boilers and air receivers, must be thoroughly examined and tested because they are subject to very heavy stresses and if parts were to fail they would fail catastrophically, leading to explosion. Pressure system periodic examination and testing should be carried out by a competent engineer at a frequency dictated by local regulation.

Equipment Controls and Environmental Factors

Equipment controls, such as stop and start buttons, should be:

- Well designed so they are easy to use.
- Placed at suitable locations on the equipment.
- Easily identifiable.
- Kept in good working order.
- Compliant with relevant standards.

It is particularly important that stop controls are easy to see and reach and that they override all other controls.

Many machines should also have emergency stops fitted. These are controls that bring the equipment to a safe stop as quickly as possible. Emergency stops can be buttons or pull cords and should be positioned on or by the equipment, within easy reach of operators. For large machines this means that several emergency stop buttons may be fitted at various locations around the machine.

Emergency Stop Button

In addition to the requirements we outlined earlier, there are some other basic physical requirements that work equipment should meet.

It should:

- Be stable – this may mean bolting it to the floor or fitting outriggers.
- Be appropriately marked – with labels on control panels, safe working loads, maximum speeds, etc.
- Have appropriate warnings – such as warning signs by dangerous parts and in some cases visible and audible warnings such as flashing beacons and klaxons to warn of the start up of machinery.

The physical environment around work equipment must also be considered, in particular lighting and space.

Lighting considerations:

- Adequate general workplace lighting should be provided around equipment for the safety of both operators and others in the vicinity.
- Local lighting, such as spotlights positioned above machinery, might be required to give higher levels of light on critical areas.
- Lighting should be suitable for the type of equipment in use; avoid lights that flicker when illuminating rotating machinery because of the "stroboscope effect" where the rate of flicker coincides with the rotation rate of the machinery giving the impression that the machinery is rotating very slowly when in reality it is rotating quickly.
- Lighting should be suitable for the environment (e.g. intrinsically safe lighting used in a flammable atmosphere).

Space considerations:

- Operators should have adequate space to move around work equipment safely.
- Other people should be able to move around safely without coming into close proximity to dangerous parts or presenting a hazard to the operator.

Operators

You will remember from your studies of Unit IGC1 that employees have a duty to take reasonable care of their own health and safety and that of others who might be affected by their acts or omissions. This is particularly relevant with regard to the operation of work equipment.

Topic Focus

Operators should:

- Only operate equipment they are authorised to use.
- Operate equipment in accordance with instruction and training.
- Only use equipment for its intended purpose.
- Carry out all necessary safety checks before using equipment.
- Not use the equipment if it is unsafe.
- Report defects immediately.
- Not use equipment under the influence of drugs or alcohol (this includes some medication which causes drowsiness).
- Keep equipment clean and maintained in safe working order.

Revision Questions

1. Why are maintenance workers sometimes at greater risk than operators when working on machinery?
2. What are the general health and safety responsibilities of machine operators?

(Suggested Answers are at the end of Unit IGC2.)

Hand-Held Tools

Key Information

- Simple hand tools can cause injury through user error, misuse or mechanical failure.
- Safe use of hand tools requires user training, compliance with safety rules, and routine inspection and maintenance of the tools.
- Portable power tools present greater risks because of the severity of injury that might be caused and the additional hazards presented by each tool.
- Safe use of power tools requires the same basic approach as that for hand tools, but with greater emphasis on user competence, supervision and maintenance, with additional precautions being introduced to combat each of the hazards associated with a tool and its power source.

Hazards and Safe Use of Hand Tools

Simple hand tools, such as a hammer, chisel or screwdriver, present relatively simple hazards:

- The tool may shatter during use, throwing off sharp metal fragments (e.g. a hammer head or chisel blade).
- The handle may come loose during use (e.g. axe head comes off handle).
- The tool may be blunt leading to use of excessive force which causes loss of control (e.g. blunt knife).
- Simple human error, where the user misjudges a movement (e.g. hits own thumb with hammer).
- The tool may be misused, i.e. used in an inappropriate way or for an inappropriate task (e.g. a screwdriver used as a crowbar).

Some relatively simple precautions can therefore be applied to ensure safe use of hand tools:

- Tools must be suitable for the task that they are going to perform and for the environment in which they are to be used, e.g. non-sparking tools (do not produce sparks when struck) are suitable for use in a potentially flammable atmosphere.
- Users should be given appropriate information, instruction and training. Many workers serve some form of apprenticeship or spend several years in training where they acquire an understanding of safety in the use of the tools for their trade, but not all workers come to the workplace with this knowledge (which may seem like common knowledge to others).
- Tools should be visually inspected routinely before use to ensure they are in an acceptable condition. This should be done by the user. Spot checks by line management will ensure that users comply. Sub-standard tools should be maintained or discarded.
- Tools should be maintained in a safe condition, e.g. blades should kept sharp and handles firmly attached.
- Supervision is important to ensure that safe working practices are adhered to and misuse does not become commonplace.

There are even hazards associated with simple tools such as hammers

Hazards and Safe Use of Portable Power Tools

Portable power tools create greater risk than simple hand tools because:

- The forces generated by the tool are far greater, so the potential for very severe injury or death exists (a ruptured disc from a disc cutter will cut an arm off, which is not going to happen with use of a hand saw).
- Power tools have additional hazards not present with simple hand tools.

Additional hazards from portable power tools are:

- Electricity – that may result in electric shock, burns, arcing or fire.
- Fuel – usually petrol, which creates a fire and explosion risk.
- Noise – which may cause hearing loss.
- Vibration – which may cause hand arm vibration syndrome.
- Dust – which is harmful if inhaled.
- Ejection – of material (e.g. brick fragments) or tool parts (e.g. cutting disc fragments).
- Trip hazards from power cables.

Construction worker using portable power tool

Because the risks created by portable power tools are greater than those associated with hand tools, the safety precautions are more stringent. Management should ensure that:

- Tools are carefully selected to ensure suitability for task and environment.
- Instructions and safety rules are available in the form of manufacturers' handbooks or in-house safe working procedures.
- Operators are trained and given information on safe use of the tool. Operator competence is a key control that should be verified.
- Operators are supervised to ensure safe use.
- Tools are routinely inspected by the operator before use. Additional formal inspections should be carried out by the supervisor or maintenance staff. Substandard tools must be repaired or discarded.
- Tools are maintained in safe working order. This might be done according to a maintenance schedule. Maintenance must be carried out by competent personnel only and records should be kept. The tool might be labelled to indicate the date of next maintenance.

In practice, safe use of a portable power tool requires that:

- Tools and parts are only used for their intended purpose, within their design specification (e.g. the maximum speed of a cutting disc should not be exceeded) and in an environment that they are suitable for.
- Necessary guards and safety devices are always used (e.g. the self-adjusting guard fitted to a portable circular saw).
- Necessary personal protective equipment is always used (e.g. eye protection when using a chain saw).
- Trailing power cables or pipes are carefully positioned so that they do not present a trip hazard and will not be damaged by the tool or passing vehicles, etc.
- Care is taken to ensure that ejected parts do not present a risk to others near by. This may require that the area is fenced or cordoned off or that the tool is only used at specific times.
- Dust exposure is controlled, either by damping down or by the use of respiratory protective equipment by the operator and others near by.
- Noise exposure is controlled, e.g. by using hearing protection (see Element 7).
- Vibration exposure is controlled, e.g. by job rotation or limiting the duration of tool use (see Element 7).

Additional precautions are necessary when storing and handling petrol. It should be **stored** in an appropriate, labelled metal container in a well ventilated secure area away from ignition sources. It should be **handled** with care in a well ventilated area (preferable outside) away from ignition sources. Any spillages should be dealt with immediately (see Element 5).

Additional precautions must be taken when using electrical equipment. Battery-operated tools might be used or low voltage supply (e.g. 110 v rather than 230 v). Damage to the electrical flex must be avoided. The tool, flex and plug should be routinely inspected by the operator prior to use. It should also be given a formal electrical safety inspection and thorough examination and test (see Element 4).

Hints and Tips

If one part of the course material proves difficult, skip over that section and carry on with the easier bits. Come back to the difficult bit later.

Revision Questions

3. (a) From what do the risks in the use of hand tools arise?

   (b) From what do the additional risks of portable power tools arise?

4. Why might each power tool be marked?

(Suggested Answers are at the end of Unit IGC2.)

Machinery Hazards and Protection – Principles

Key Information

- The mechanical hazards of machinery are: crushing, shearing, cutting or severing, entanglement, drawing in or trapping, impact, stabbing or puncture, friction or abrasion, and high pressure fluid injection.
- The non-mechanical hazards of machinery are: electricity, noise, vibration, hazardous substances, radiation (ionising and non-ionising), extreme temperatures, ergonomics, slips, trips and falls, and fire and explosion.
- Protection from machinery hazards can be achieved by using guards that physically enclose the hazard and prevent contact. Fixed guards are most effective at preventing contact, but interlocked guards, adjustable guards and self-adjusting guards may be required.
- If it is not possible to completely guard in a hazard then other forms of protection will have to be used such as trip devices, two-hand controls, protective appliances, emergency stops, PPE, or information, instruction, training and supervision.
- Guards and safety devices must meet relevant standards: be strong and robust; compatible with machine operation; not easy to defeat; allow visibility and ventilation; take maintenance into account; and not increase overall risk.

Mechanical and Non-Mechanical Hazards

The hazards of machinery can be divided into:

- Mechanical hazards – mainly from contact with or being caught by dangerous moving parts.
- Non-mechanical hazards – mainly from the power source or things emitted by the machine.

This follows ISO 12100:2003 (Parts 1 and 2) "Safety of Machinery".

Mechanical Hazards

The mechanical hazards of machinery can be further subdivided into the following classes:

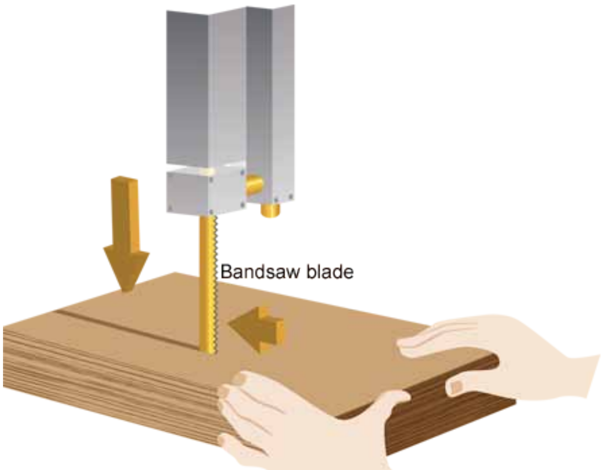
Crushing – the body is trapped between two moving parts or one moving part and a fixed object (e.g. a hydraulic lift collapses crushing a person underneath it).

Crushing – the person is crushed between the moving object and the wall

Shearing – a part of the body (usually fingers) is trapped between two parts of the machine, one moving past the other with some speed. The effect is like a guillotine, shearing off the trapped body part.

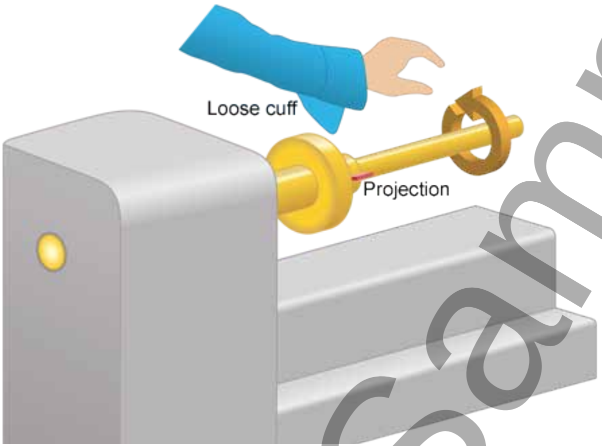
Shearing – a finger put through the spokes of this wheel will be sheared off

Cutting or severing – contact is made with a moving sharp-edged part such as a blade (e.g. the blade of a bandsaw).



Cutting or severing – if the hands come into contact with the moving blade severe laceration or amputation will occur

Entanglement – loose items such as clothing or hair get caught on a rotating machine part and the person is drawn onto the machine.



Entanglement – a loose sleeve cuff becomes entangled with the chuck of a lathe

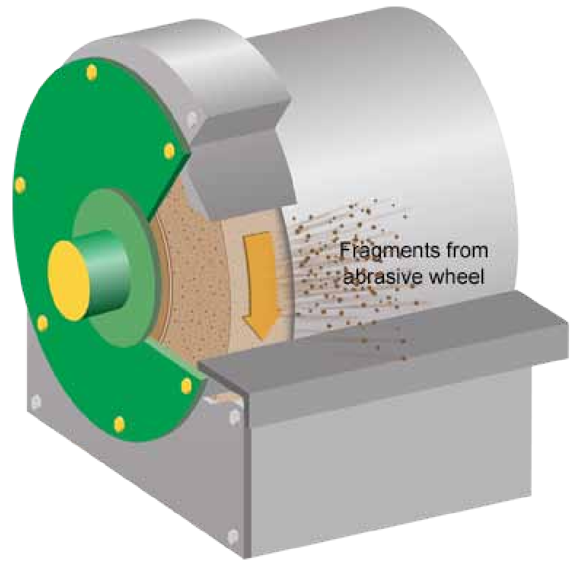
Drawing in or trapping - a part of the body is caught between two moving parts and drawn into the machine, e.g. at "in-running nips" where two counter-rotating rollers meet.

Drawing in or trapping - if the rollers are touched at the in-running nip point then the hand will be drawn in by the two rollers

Impact – the body is struck by a powered part of a machine (this is similar to crushing, but there is no fixed structure to trap the person; the speed and weight of the object does the damage).

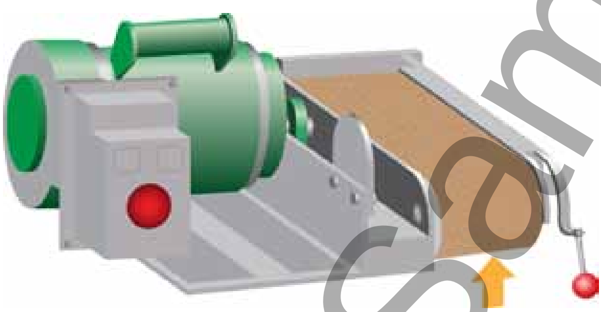
Impact – the person is struck hard by the heavy and fast-moving industrial robot

Stabbing or puncture – sharp parts of the machine, or parts or material ejected from the machine, penetrate the body (e.g. swarf, sewing machine needle, abrasive wheel fragments, nails from a nail gun).



Stabbing or puncture – small fragments of the abrasive wheel are ejected at high speed and can cause penetration injury, particularly to the eyes

Friction or abrasion - contact is made with a fast-moving surface which may be smooth (e.g. touching a spin dryer) or rough (e.g. touching a belt sander).



Friction or abrasion – if the belt is touched whilst in motion then abrasion occurs

High pressure fluid injection – fluid at very high pressure is ejected from the machine and penetrates the skin (e.g. hydraulic fluid escaping from a burst hydraulic hose).

Non-Mechanical Hazards

The non-mechanical hazards of machinery are those hazards that do not arise directly from contact with dangerous moving parts. They are mainly associated with the power source of the machine or are things that it emits. In other words, they are all the hazards that remain once the mechanical hazards have been listed.

Topic Focus

The non-mechanical hazards of machinery:

- Electricity
- Noise
- Vibration
- Hazardous substances
- Ionising radiation
- Non-ionising radiation
- Extreme temperatures
- Ergonomics
- Slips, trips and falls
- Fire and explosion.

We will cover these hazards in other Unit IGC2 elements, so here we will just clarify two issues:

- Hazardous substances are often contained or used by machinery as an integral part of the process, e.g. a metal cutting lathe uses cutting fluid to cool and lubricate the cutting bit. In other instances hazardous substances are produced as a by-product of machine operation, e.g. a robot welder produces welding fumes.
- Ergonomic hazards result from the interaction of the machine operator and the machine - from the posture that the operator has to adopt during machine use and the stresses put on the body. For example, a construction worker using a concrete breaker may have to support the weight (say 8 kg) of the breaker in order to cut a hole for a door lintel.

Machine Guards, Protective Devices and Other Methods of Protection

It may be possible to eliminate the risk created by a piece of machinery by getting rid of the machine that creates the risk. However, this is not an option in most circumstances.

It is also possible that the hazards associated with a piece of machinery can be eliminated by good design. This is the job of the manufacturer and statute law usually exists to ensure that this approach is taken. But even when this is done hazards will still remain.

It is, therefore, essential that further safeguards are used to control the remaining hazards. The best approach is to create a safe machine using engineering controls (such as fixed guards). In some situations it is not possible to guard in a machine hazard and then other devices and appliances have to be applied.

Some hazards cannot be controlled by engineering means at all and then safety depends solely on operator behaviour. This is, of course, the least preferred option because operators are prone to human error and commit violations.

Here we look at each of the safeguards that might be used, in order of preference. Usually a combination of the various safeguards is used to reduce risk to an acceptable level.

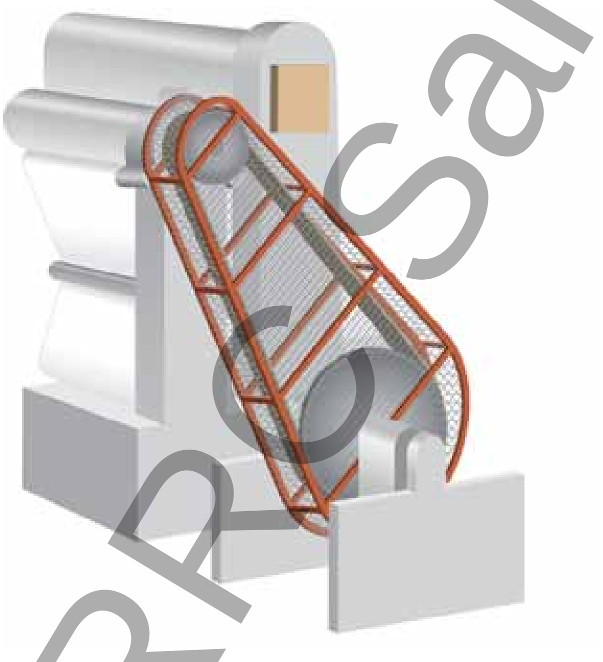
Fixed Guards

A fixed guard is a physical barrier that prevents a person from coming into contact with dangerous moving parts. The guard may by shaped to fit the machine quite closely (enclosing guard), or it may be more like a fence around the machine (perimeter guard). It may have openings in it (e.g. to allow raw material to be fed into a machine), but these must be designed in such a way that it is not possible to reach in and contact dangerous parts (distance guard).

Basic principles of a fixed guard:

- It completely prevents access to dangerous parts.
- It is fixed in place.
- Fixings require a tool for removal – the guard must not be removable by finger force alone.

Fixed guards are often made of sheet metal. If ventilation (e.g. to prevent overheating of machine parts) or visibility into the machine is required, then a mesh guard or Perspex guard might be used instead. If a mesh guard is used then care must be taken to ensure that the mesh size is not so large as to allow access to dangerous parts.



A fixed enclosed guard on a belt drive mechanism – this guard is made of mesh to allow ventilation and visibility (Based on original source L22 Safe Use of Work Equipment)

The main **disadvantage** of a fixed guard is also its main strength - it totally prevents easy access into the machine. There are many situations where easy access into a machine is necessary for machine operation, setting or cleaning. When routine access inside a guard is required a fixed guard should not be used. If it is, then the operator is very likely to leave the guard off because it is interfering with machine operation.

Interlocked Guards

An interlocked guard is designed to be removed as a normal part of routine machine operation. When the guard is removed a safety interlock system prevents machine operation. For example, a microwave oven has a hinged door on the front to allow easy access; this door is interlocked so that power to the microwave generator is shut off when it is open.

Basic principles of an interlocked guard:

- Power to the machine is disabled and the machine will not operate until the guard is in place.
- Either the guard is locked shut until it is safe for the guard to open, or the act of opening the guard stops the dangerous parts and disables power.

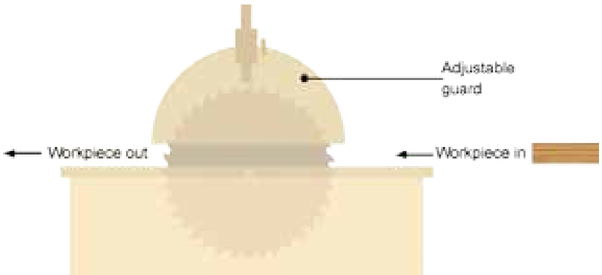
Many machines are fitted with interlocked doors which when opened bring the moving parts to an immediate stop (e.g. photocopier). However, some machines cannot be stopped in this way and it is then preferable to use an interlocked guard that locks shut and can only be opened once the danger has passed (e.g. domestic washing machine).

The main **limitation** of an interlocked guard is that it is possible to bypass the system so that the machine can be operated with the guard open. With simple interlock systems this is easily done, but even complex interlock systems can be defeated by a determined person. It is, therefore, important that the appropriate type of interlock system is fitted to the machine and that strict rules are imposed about safe use of interlocked guards.

Adjustable and Self-Adjusting Guards

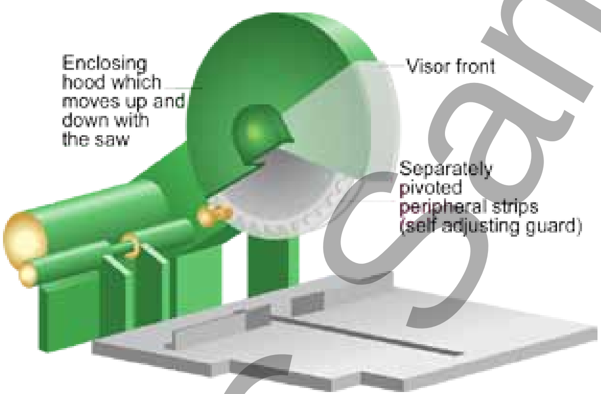
Adjustable and self-adjusting guards are used when it is not possible to completely prevent access to dangerous parts. They are commonly used to safeguard woodworking and metalworking machinery where a workpiece has to be fed into the machine or manipulated during machine use.

An **adjustable guard** can be set to a range of positions by the operator depending on the nature of the workpiece and the operation being carried out. For example, the top guard on a bench-mounted circular saw can be set at a range of heights depending on the size of wood being cut.



Adjustable guard over blade of bench-mounted circular saw; the guard covers most of the blade, but a section remains exposed so that wood can be fed through

A **self-adjusting guard** does the same thing but is sprung loaded or linked to other machine parts. As the machine operates the guard adjusts automatically to fit the workpiece. It does not require the operator to set it to the right position.



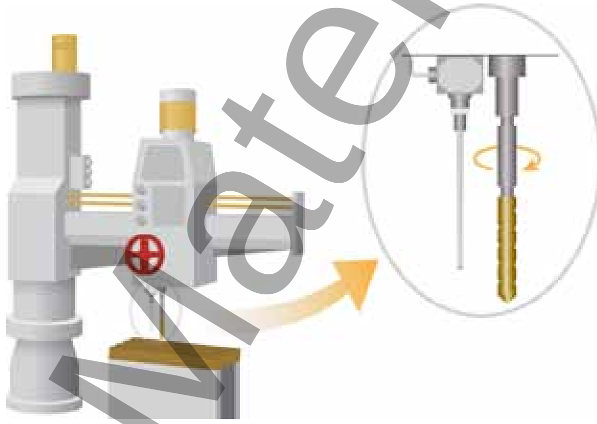
Self-adjusting guard on a crosscut mitre saw; as the saw moves down the guard retracts to expose the blade

Main **limitations** with adjustable and self-adjusting guards:

- Do not completely prevent access to dangerous parts.
- Very easy to defeat.
- Rely 100% on operator competence.

Trip Devices

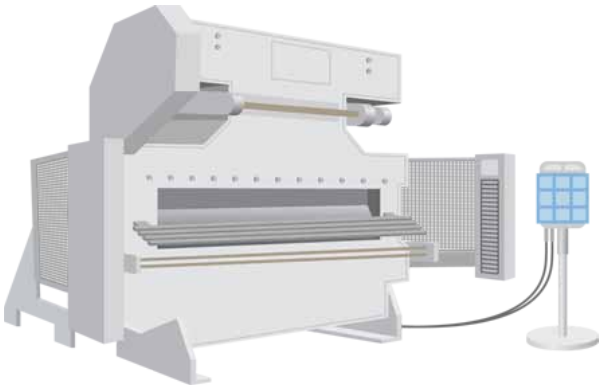
Trip devices are protective devices that do not put a physical barrier between the operator and the dangerous parts of machinery. Instead some form of sensor is used to detect the presence of the operator and stop the machine.



Trip bar fitted to a drilling machine; if the bar is hit, the drill emergency stops. Note that the bar does not prevent entanglement, but simply reduces the severity of injury.

There are different types of trip devices:

- **Pressure mats** – mats placed on the floor around an item of machinery such as an industrial robot. If a person stands on the mat their weight activates the trip and the robot stops moving.
- **Trip bars** – wands or rods placed close to dangerous parts which when touched will stop machine movement.
- **Photoelectric devices** – shine beams of light across an access point. If the beams are broken then the machine is stopped.



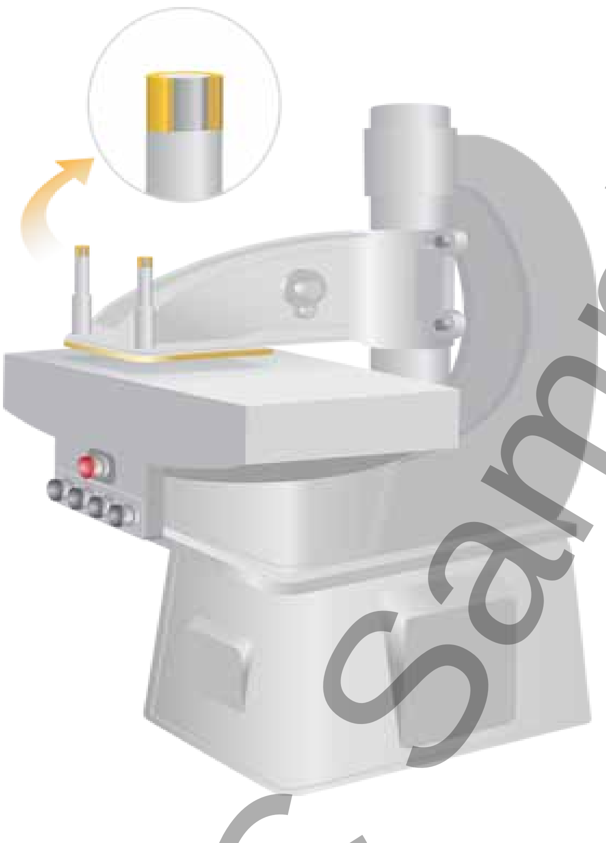
A photoelectric device fitted to a press brake; the device forms a curtain of beams across the front of the machine (Based on original source L22 Safe Use of Work Equipment)

Main **limitations** of these trip devices:

- Do not provide a physical barrier to prevent access.
- May be overly sensitive, leading to frequent trips which will encourage the operator to bypass or disable them.
- More complicated than simple physical guards and may therefore fail more frequently which encourages misuse.

Two-Hand Controls

These are a way of protecting the machine operator's hands where operation of the machine can only be achieved when two start buttons are pressed at the same time. They are often used when routine machine use requires the operator to put their hands inside or under a machine where they are at risk from machine operation.



Two-hand controls on a click press; the operator is at risk of a crushing injury if the press operates when their hand is between the top and bottom plates

The idea is that the machine will only operate when the operator has both hands on the controls.

Important principles of two-hand controls:

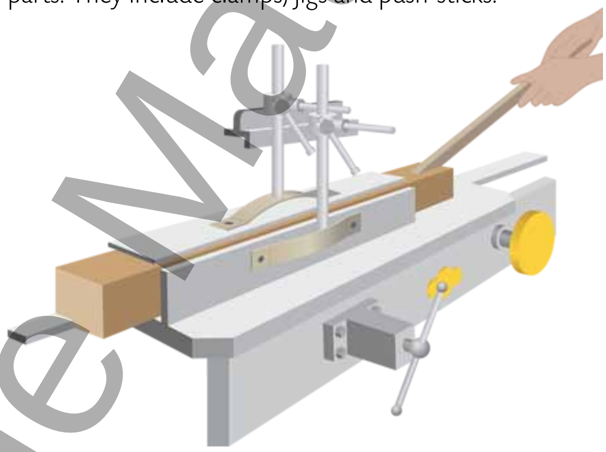
- Controls must be more than one hand span apart (to prevent one-handed operation).
- Controls must have to be activated simultaneously (to prevent the operator jamming one button down permanently).
- Releasing the controls must stop the machine immediately.

Main **limitations** of two-hand controls:

- Do not protect other parts of the body.
- Relatively easy for two operators working together to bypass the system.

Protective Appliances

Protective appliances are pieces of equipment that allow an operator to keep their hands away from dangerous parts. They include clamps, jigs and push-sticks.



A push-stick is used to push a workpiece through a woodworking machine. The push-stick is simply a piece of wood with a V-shaped notch cut in one end

Emergency Stop Controls

We described emergency stops earlier in this element. They can be buttons or pull cords and should be positioned at easily reached positions on the machine and associated control panels.

Key principles of emergency stops:

- Should bring the machine to a safe stop as quickly as possible.
- Should latch or lock in so that the machine can only be restarted by going to the location of the button to reset it.
- Release of the button should not restart the machine.

Emergency stop buttons should never be used as a substitute for machine guarding or protection devices. They are intended to provide an additional level of protection in case other safeguards fail.

Main **limitations** of emergency stops:

- Only used once danger has been sensed by the operator and by then it may be too late.
- Despite good design a person trapped by a machine may not be able to reach the emergency stop.
- May not be possible to emergency brake the machine quickly enough to prevent injury.

Personal Protective Equipment

PPE should only be used as a last resort after other, more reliable, protection options have been exhausted. Inevitably, though, some of the hazards associated with machinery cannot be designed out or safeguarded by any other means and then PPE becomes appropriate.

A wide range of PPE is available to protect machine operators from one or more hazards associated with the machine that they are operating, e.g. respiratory protective equipment may be used to prevent inhalation of hazardous fumes, dust or mist emitted by the machine.

One item of PPE commonly used by machine operators is eye protection. Safety spectacles, goggles or face visors may be used to prevent impact injury to the eye. Such eye protection must always be selected with reference to the relevant regional standards.

You will have studied the general limitations of PPE in Unit IGC1; however, one particular issue that is worth noting here is that sometimes the use of gloves is inappropriate because it increases the risk of entanglement or drawing in and may increase the severity of injury that results.

Worker wearing PPE

Information, Instruction, Training and Supervision

Appropriate information, instruction, training and supervision (IIT&S) must be provided to machine operators. The question of how much IIT&S is appropriate can be answered by considering the level of risk associated with the machinery and by reference to legal standards and codes of practice.

In particular IIT&S becomes important where the level of risk is high and it has not been possible to use other controls to safeguard the machinery. So, for example, very little IIT&S has to be done when introducing a document shredder into an office because the machine will be very well safeguarded already; simply asking users to read the instruction manual and then checking to ensure that they do not misuse the machine should be sufficient. But with an item of woodworking machinery, where there is the risk of serious injury and safe use of the machinery is less reliant on fixed and interlocked guards and far more reliant on safe operating procedures, then far more IIT&S has to be provided.

Requirements for Guards and Safety Devices

Guards and safety devices must be suitable. If they are not, then they will not fulfil their function, the machine may not operate correctly, or the operator may come under pressure to remove or defeat them.

Topic Focus

Basic characteristics of a guard or safety device:

- Meets relevant standards – with regards to preventing contact with dangerous parts.
- Strong and robust - to withstand the forces it may be subjected to.
- Compatible – must not interfere with machine operation.
- Not easy to defeat or bypass.
- Vision – must not interfere with any need to see in.
- Ventilation – must not interfere with any ventilation required.
- Ease of maintenance – should be easy to maintain.
- Removal for maintenance – ideally the guard should not have to be removed to allow maintenance on the machine to take place.
- Does not increase overall risk.

Revision Questions

5. What are drawing-in injuries?
6. List the non-mechanical hazards arising from the use of machinery.
7. What is the hierarchy of protective measures?
8. Describe the principles of an interlocking guard system.
9. What is a trip device?
10. What are the limitations of adjustable guards?
11. What are protective appliances?
12. When are operators required to be trained in the use of safety equipment?
13. How may two-handed controls be over-ridden?
14. What five requirements are there for any guarding system?

(Suggested Answers are at the end of Unit IGC2.)

Machinery Hazards and Protection – Specific Examples

Key Information

- All machinery, from simple office machinery (such as a photocopier or document shredder) to construction machinery (such as a cement mixer or bench-mounted circular saw), present a range of both mechanical and non-mechanical hazards.
- Guards and other protection methods have to be used to control the risk associated with all such types of machinery.

Specific Machinery Examples – Hazards and Protection

The following examples illustrate the hazards and protection methods associated with typical machines found in different types of workplaces.

Office Machinery

Photocopier: Hazards

- Drawing in and entanglement from contact with moving parts.
- Electricity.
- Contact with hot parts.
- Health hazard from ozone (irritant gas).

A typical photocopier

Protection

- Fixed and interlocked guards enclosing all mechanical hazards.
- Routine inspection and portable appliance testing.
- Use in a ventilated room.

Paper Shredder: Hazards

- Cutting and drawing in (in-running nip between cutter blades).
- Electricity.
- Ergonomic from handling of waste.

A typical paper shredder

Protection

- Fixed and interlocked guards enclosing mechanical hazards.
- Routine inspection and portable appliance testing.

Manufacturing and Maintenance Machinery

Bench-Top Grinder: Hazards

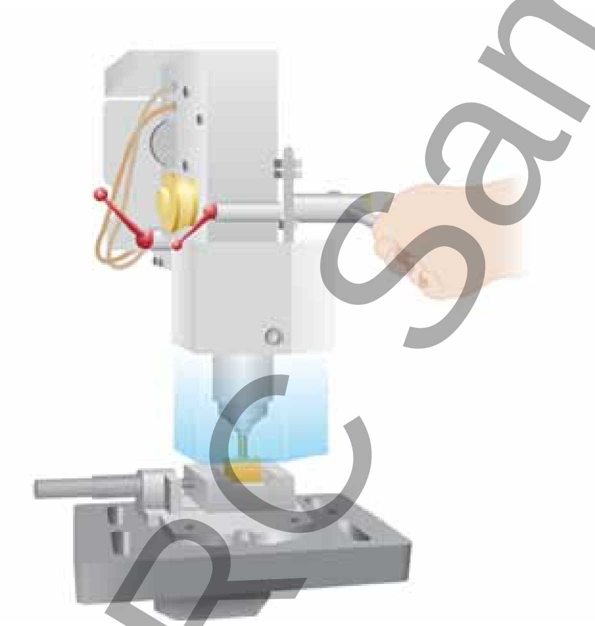
- Abrasion on contact with rotating abrasive wheel.
- Drawing in at nip-point between wheel and tool rest.
- Puncture by ejected parts of the wheel during normal use or if it bursts.
- Entanglement with the spindle on which the wheel is mounted.
- Electricity.
- Hot parts caused by friction (especially the workpiece being ground).
- Health hazard from dust.
- Noise.

Protection

- Fixed enclosing guards around motor and part of abrasive wheel.
- Adjustable polycarbonate eye guards over exposed part of wheel.
- Tool rest adjusted to minimise nip point between rest and wheel.
- Use and setting restricted to trained operators only.
- Eye protection (impact resistant).
- Hearing protection may be necessary.
- Routine inspection and portable appliance testing.

Pedestal Drill: Hazards

- Entanglement with the rotating drill bit or chuck.
- Stabbing or puncture by the drill bit during normal use or if the bit breaks.
- Puncture by swarf ejected during metal cutting.
- Impact if struck by the workpiece if the bit jams and the workpiece rotates.
- Drawing in at nip-points between motor and drive belts.
- Electricity.
- Noise.
- Hot parts (especially the drill bit).
- Health hazard from cutting fluid (e.g. dermatitis).



Pedestal Drill

Protection

- Fixed guards over motor and drive mechanisms.
- Adjustable (possibly interlocked) guard over chuck and drill bit.
- Clamp to secure workpiece to base.
- Eye protection (impact resistant).
- Hearing protection may be necessary.
- Routine inspection and portable appliance testing.
- Use restricted to trained operators only.

Agricultural and Horticultural Machinery

Cylinder Mower (petrol driven, ride-on type): Hazards

- Cutting on contact with moving blades.
- Impact or crushing if struck by the mower.
- Entanglement with various rotating parts.
- Drawing in at various nip-points.
- Noise.
- Vibration.
- Fire and explosion from petrol (fuel).
- Health hazard from sensitisation to grass sap, pollen, etc.

Protection

- Fixed guards over drive mechanism.
- Safety switch under seat to ensure that driver is in seat before machine will operate.
- Use restricted to trained operators only.
- Hearing protection.
- Refuelling carried out in well-ventilated area.
- Job rotation may be necessary to limit vibration exposure.
- Use restricted for workers with sensitisation.

Strimmer or Brush-Cutter (petrol driven): Hazards

- Cutting on contact with moving cutting head.
- Entanglement with rotating cutting head.
- Puncture by objects ejected by cutting head (e.g. stones).
- Noise.
- Vibration (into hands).
- Fire and explosion from petrol (fuel).
- Ergonomic from repetitive movement, twisting, carrying.

- Health hazards from sensitisation to grass sap, pollen, etc.
- Health hazard from ejected/atomised animal faeces.

Protection

- Fixed enclosing guards over motor and drive mechanism.
- Partial side guards fitted around cutter head.
- Safety interlocked throttle trigger to prevent accidental operation of throttle.
- Face and eye protection (impact resistant).
- Hearing protection.
- Stout gloves, boots (steel toe-cap), trousers and shirt.
- Job rotation may be necessary to limit vibration exposure.
- Harness to support and balance weight of machine.
- Refuelling carried out in well-ventilated area.
- Use restricted to trained operators only.
- Use restricted for workers with sensitisation.

Chainsaw (petrol driven): Hazards

- Cutting on contact with moving blade.
- Entanglement with moving blade.
- Drawing in at nip-point between blade and casing.
- Puncture by ejected parts (especially broken blade fragments).
- Noise.
- Vibration (into hands).
- Fire and explosion from petrol (fuel).
- Ergonomic from handling.
- Heath hazards from dust and sap.

Protection

- Appropriate PPE (see Topic Focus).
- Fixed enclosing guards over motor and drive mechanism.
- Hand guard for front hand grip.
- Chain brake to stop chain in event of kick back.
- Safety interlocked throttle trigger to prevent accidental operation of throttle.
- Job rotation may be necessary to limit vibration exposure.
- Refuelling carried out in well-ventilated area.
- Use restricted to trained operators only.

Topic Focus

Personal protective equipment when using a chainsaw:

- Face (visor) and eye protection (impact resistant).
- Hearing protection.
- Head protection (hard hat) may be necessary.
- Stout gloves.
- Boots with good grip and steel toe-caps.
- Cut-resistant trousers or chaps.
- Stout shirt.

Wearing appropriate PPE while using a chainsaw

Retail Machinery

Compactor: Hazards

- Crushing if inside during operation.
- Shearing between moving arms during operation.
- Crushing or impact by ejected bale or container lorry.
- Electricity.
- High pressure fluid ejection from hydraulic system.
- Ergonomics from handling material during loading.

Protection

- Fixed perimeter guard around loading area and mechanism.
- Interlocked guard to allow access to loading area.
- Routine inspection and portable appliance testing.
- Use restricted to trained operators only.

Checkout Conveyor System: Hazards

- Drawing in at nip-points on belt system (e.g. where belt meets counter top).

- Entanglement with motor or rollers driving the belt.
- Friction on contact with moving belt.
- Electricity (motor).
- Ergonomics from handling items whilst seated.
- Non-ionising radiation from the laser bar-code scanner.

Protection

- Fixed and interlocked guards to motor and drive mechanism.
- Trip fitted to conveyor to prevent drawing in.
- Routine inspection and portable appliance testing.
- Use restricted to trained operators only.

Construction Machinery

Cement Mixer: Hazards

- Entanglement with rotating drum or drive motor.
- Drawing in at nip-point between motor and drive mechanism.
- Crushing between drum and drum stop when tipping.
- Friction or abrasion on contact with moving drum.
- Electricity.
- Ergonomics from handling during loading.
- Health hazard from cement dust inhalation and contact with wet cement (corrosive).

Protection

- Fixed guards to motor and drive mechanism.
- Routine inspection and portable appliance testing.
- Use restricted to trained operators only.
- Hand protection and eye protection (splash resistant).

Bench-Mounted Circular Saw: Hazards

- Cutting on contact with blade.
- Entanglement with drive motor.
- Drawing in at nip-points between motor and drive belt.
- Ejection of workpiece during cutting.
- Electricity.
- Noise.
- Health hazard from inhalation of wood dust.

Protection

- Fixed guard fitted to motor and bottom of cutting blade.
- Adjustable top guard fitted above blade.
- Riving knife fitted behind blade (prevents the timber from pinching shut on the saw blade after it has been cut – which can lead to the timber being kicked back towards the operator).
- Hearing protection.
- Eye protection (impact resistant).
- Extraction ventilation or respirator may be necessary.
- Routine inspection and portable appliance testing.
- Use restricted to trained operators only.

More...

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

Revision Questions

15. What hazards might arise from the use of the following machines?
    (i) Bench top grinder.
    (ii) Chainsaw.
    (iii) Bench-mounted saw.
16. List the PPE that should be worn when using a chainsaw.

(Suggested Answers are at the end of Unit IGC2.)

Summary

This element has dealt with some of the hazards and controls relevant to work equipment.

In particular this element has:

- Described some of the basic management issues that must be considered when introducing work equipment such as:
  - Suitability for task and environment.
  - Restriction of use to competent operators.
  - Information, instruction and training.
  - Inspection and maintenance requirements.
  - Marking and positioning of controls.
  - Stability, lighting and space requirements.
  - Operator behaviour.
- Outlined the hazards and precautions associated with simple hand tools such as hammers and chisels.
- Outlined the hazards and precautions associated with portable power tools such as a portable electric drill or disc cutter.
- Explained the mechanical hazards of machinery as: crushing; shearing; cutting or severing; entanglement; drawing in or trapping; impact; stabbing or puncture; friction or abrasion; and high pressure fluid injection.
- Identified the non-mechanical hazards of machinery as: electricity; noise; vibration; hazardous substances; radiation (ionising and non-ionising); extreme temperatures; ergonomics; slips, trips and falls; and fire and explosion.
- Explained the basic characteristics of fixed guards, interlocked guards, adjustable guards and self-adjusting guards as well as the characteristics of trip devices, two-hand controls, protective appliances and emergency stops.
- Outlined the basic requirements of guards and safety devices, such as: must meet relevant standards; be strong and robust; compatible with machine operation; not easy to defeat; allow visibility and ventilation; take maintenance into account; and not increase overall risk.
- Described the hazards associated with photocopiers, shredders, bench grinders, pedestal drills, cylinder mowers, strimmers, chainsaws, compactors, checkout conveyors, cement mixers and bench-mounted circular saws.
- Identified the types of guard and other protection measures to ensure safety in the use of photocopiers, shredders, bench grinders, pedestal drills, cylinder mowers, strimmers, chainsaws, compactors, checkout conveyors, cement mixers and bench-mounted circular saws.

Question

(a) **Identify** hazards associated with the use of a cement mixer. (4)

(b) For the hazards identified above **outline** control measures that can be used to reduce the risks. (4)

Approaching the Question

Think now about the steps you would take to answer the question:

1. The first step is to read the question carefully. Note that part (b) of this question asks you to **outline** control measures. We haven't tackled an "outline" question in IGC2 yet, and it is a very common NEBOSH question type. An outline is defined as "give the key features of". You need to give a brief description of something or a brief explanation of reasons why. This is less depth than "explain" or "describe" but more depth than "list". A great amount of depth and detail is not required.

   So in this question you are required to identify hazards associated with cement mixers, then outline control measures that are used to reduce **those** hazards.

2. Next, consider the marks available. In this question there are eight marks so it is expected that around eight or nine different pieces of information should be provided. Questions that are split into parts (this one is split into two parts worth four marks each) are often easier to pick up marks on, because the signposts NEBOSH use are so much easier to see. You will be expected to provide four pieces of information for each part of the question; the whole question should take around eight minutes. As we have said previously, if you want to provide a few additional pieces of information and you have the time to do so it is fine – this might help you to achieve maximum marks. However, if a question **specifically** asks for four facts, then you must only give four as any others won't be marked. Here it's OK as it's only implied from the mark scheme.

3. Now highlight the key words. In this case they might look like this:

   (a) **Identify** hazards associated with the use of a cement mixer. (4)

   (b) For the hazards identified above outline control measures that can be used to reduce the risks. (4)

4. Read the question again to make sure you understand it and have a clear understanding of the hazards associated with the use of cement mixers and their control measures. (Reread your notes if you need to.)

5. The next stage is to develop a plan – there are various ways to do this. Remind yourself, first of all, that you need to be thinking about 'hazards' for the first part; and 'controls' for the second part.

   The answer plan will take the form of a bullet-pointed list that you need to develop into a full answer based on the key words that you have highlighted.

Now have a go at the question. Draw up an answer plan, and then use it as the basis to write out an answer as you would in the exam.

Key hint: don't just think of mechanical (machinery) hazards – there are lots of potential hazards associated with the use of a cement mixer.

Remember, you can always contact your tutor if you have any queries or need any further guidance on how to answer this question.

When you have finished, compare your plan and full answer with those that follow.

Suggested Answer

Plan

Cement Mixer Hazards	Corresponding Controls
• Ejection of materials.	• Guards to contain contents.
• Entanglement in moving parts.	• Guards to prevent access.
• Chemical hazards (irritant and corrosive).	• PPE including gloves, goggles, overalls.
• Inhalation of dusts.	• Use of RPE to prevent inhalation.
• Noise.	• Use of ear defenders.
• Electrocution (if electrically powered)	• Maintenance and use of RCD.
• Contact with diesel/fumes if diesel-powered.	• Adequate ventilation, safe storage of fuels.
• Manual handling.	• Mechanical lifting aids, reduction in cement bag size, training.

Possible Answer by Exam Candidate

(a) *Hazards associated with the use of a cement mixer include:*

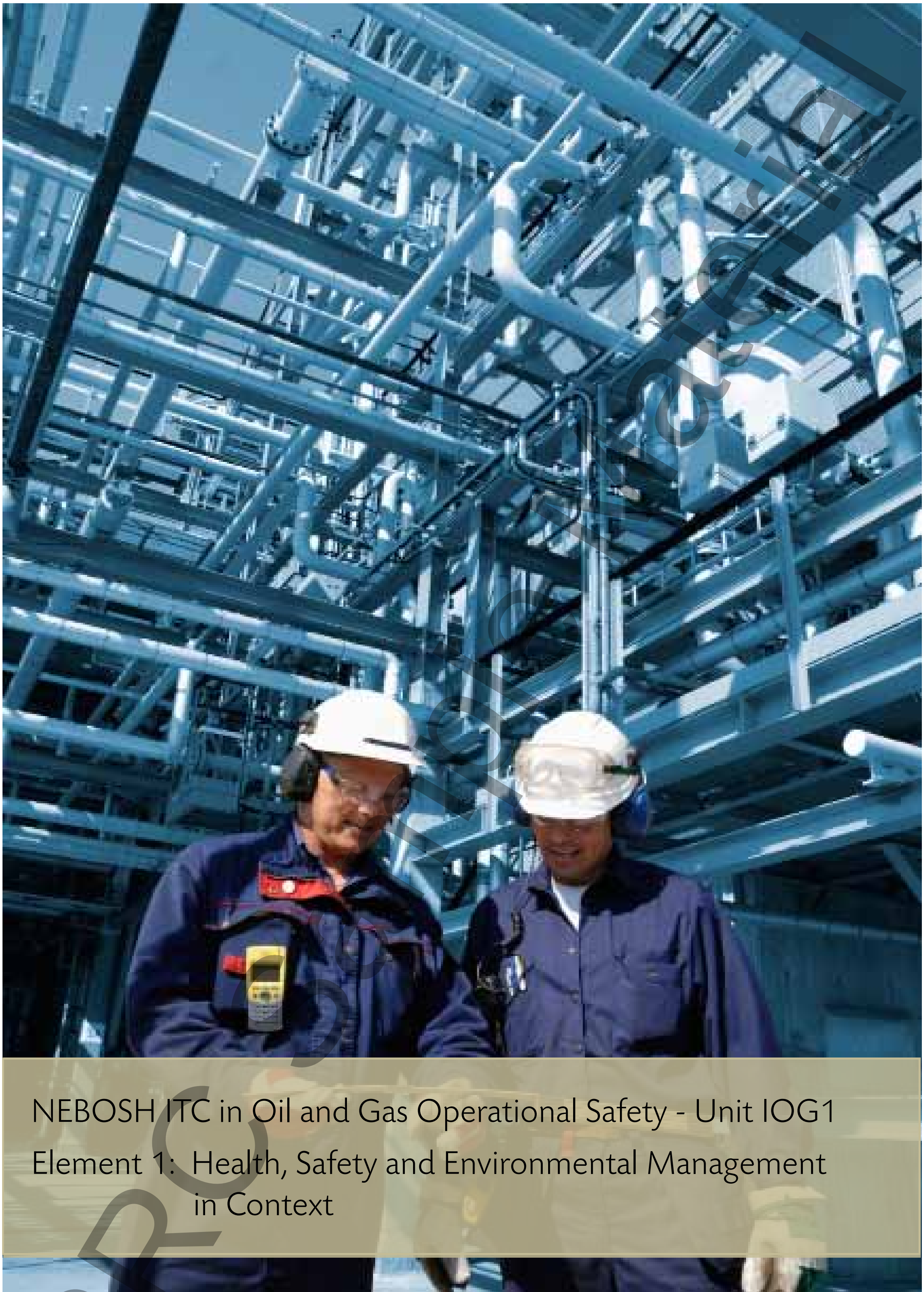
- *The ejection of materials from the moving drum.*
- *Contact with moving parts resulting in entanglement or abrasion.*
- *Contact with the corrosive cement and inhalation of irritant dusts.*
- *Noise during the operation of the mixer.*
- *Electrocution from an electrically-powered mixer.*
- *Manual handling of the cement bags.*

(b) *Corresponding controls to reduce the risk could include the following. Guards could be installed in order to contain debris and prevent ejection of materials, while also preventing access to moving parts of the mixer. PPE, including gloves, eye protection and overalls could be used to protect from the corrosive cement, while dust masks could be used to prevent inhalation of cement dusts. Maintenance may reduce the noise levels; however, hearing protection, e.g. ear plugs, could be used to further reduce the risk. The risk of electric shock could be reduced by using reduced voltage (110V) power supplies, or if not possible an RCD could be used. Finally manual handling could be reduced by using mechanical lifting aids, reducing bag sizes, using team lifting and providing training in safe lifting techniques.*

Reasons for Poor Marks Achieved by Candidates in Exam

As before, bullets have been used with care in the above example answer – this is not a list and the correct level of detail for an "identify" question has been used.

Most candidates managed this question well. However, some did lose marks for not providing sufficient detail for an "outline" as required in part (b).



NEBOSH ITC in Oil and Gas Operational Safety - Unit IOG1

Element 1: Health, Safety and Environmental Management in Context

RRC TRAINING

Contents

Learning Outcomes

On completion of this element, you should be able to demonstrate understanding of the content through the application of knowledge to familiar and unfamiliar situations. In particular you should be able to:

- Explain the purpose of and procedures for investigating incidents and how the lessons learnt can be used to improve health and safety in the oil and gas industries.
- Explain the hazards inherent in oil and gas arising from the extraction, storage, and processing of raw materials and products.
- Outline the risk management techniques used in the oil and gas industries.
- Explain the purpose and content of an organisation's documented evidence to provide a convincing and valid argument that a system is adequately safe in the oil and gas industries.

Hints and Tips

Before you begin studying your course material, take a very quick look through the whole of IOG1. Don't read any of the information in detail - just aim to get an overview of the big picture and an idea of what you will be learning about later. Look out for the different Hints and Tips boxes too.

Learning From Incidents

Key Information

- Investigating accidents and near-misses is important, as is effective root cause analysis and the recommendation of improvements, in order to make every effort to avoid future incidents.
- Lessons can be learnt from major incidents, especially with regard to management, cultural and technical (process) failures that lead to incidents occurring.

Investigating Incidents and Near-Misses

When an incident or near-miss occurs in the workplace, it should be recorded and investigated. The main reason for this is that having happened once, it may happen again; and when it happens again the outcome may be as bad as, or worse, than it was the first time. We must therefore attempt to understand exactly why the incident happened so that corrective actions can be taken to prevent a recurrence.

Near-misses are an indicator of accident potential. Often the only thing that separates a near-miss from an accident is luck – so regard each near-miss as a "free warning".

All incidents and near-misses in the workplace should be recorded and investigated.

All incidents should be examined to determine the potential for serious harm. Where this potential exists, a thorough investigation should be carried out to prevent that harm from becoming actual. This is not to say that all incidents should be investigated in great depth and detail – that would be a waste of time and effort in many cases; but it is to say that all incidents should be examined for the potential for serious harm so a decision can be made as to whether more detailed investigation is required. This idea is sometimes formalised into an organisation's incident investigation procedure.

Topic Focus

Reasons for carrying out an incident investigation:

- To identify the immediate and root causes of the incident – incidents are usually caused by unsafe acts and unsafe conditions in the workplace, but these often arise from underlying or root causes.
- To identify corrective actions that will prevent a recurrence – the main reason for investigating.
- To record the facts of the incident – people do not have perfect memories and investigation records document the factual evidence for the future.
- For legal reasons – incident investigations can be an implicit legal duty imposed on the employer.
- For claims management – if a claim for compensation is lodged against the employer the insurance company will want to examine the incident investigation report to help determine liability.
- For staff morale – non-investigation of incidents has a detrimental effect on morale and safety culture because workers will assume that the organisation does not value their safety.
- For disciplinary purposes – although blaming workers for incidents has a negative effect on safety culture, there are occasions when an organisation has to discipline a worker because their behaviour has fallen short of the acceptable standard.
- For data gathering purposes – incident statistics can be used to identify trends and patterns; this relies on the collection of good quality data.

Types of Incident

- **Near-miss** – an unplanned event that had the potential to cause injury, ill-health, loss or damage but did not, in fact, do so (a worker was narrowly missed by oil spurting from a burst pipeline).
- **Accident** – an unplanned, unwanted event which leads to injury, damage or loss.
  - **Injury accident** – where an unplanned, unwanted event leads to some sort of personal injury (e.g. a cut hand).
  - **Damage only accident** – where the unplanned, unwanted event leads to equipment or property damage, or loss of materials, etc. (e.g. a wall is knocked down by a vehicle).
- **Dangerous occurrence** – a specified event that has been reported to the relevant authority by statute law (e.g. a major gas release).
- **Ill-health** – a disease or medical condition that is directly attributable to work (e.g. dermatitis from exposure to oils and greases).

It is important to remember the importance of investigating **all** of the above types of incident, not just those we expect to lead to fatalities or major injury.

Basic Investigation Procedures

There are some basic principles and procedures that can be used when investigating an incident:

Step 1: Gather factual information about the event.

Step 2: Analyse that information and draw conclusions about the immediate and root causes.

Step 3: Identify suitable corrective measures.

Step 4: Plan the remedial actions.

However, before the investigation can begin there are two important issues that have to be considered:

- **Safety of the scene** – is the area safe to approach? Is immediate action needed to eliminate danger even before casualties are attended to?
- **Casualty care** – any injured people will require first-aid treatment and possibly hospitalisation. This is a priority. The welfare of uninjured bystanders also has to be taken into account - they may be suffering shock.

Once the immediate dangers have been dealt with and casualties attended to, a decision should be made regarding the type and level of investigation that is needed. Should it be:

- A relatively simple investigation of an incident that caused only minor outcomes and did not have the potential for serious outcomes?
- A more in-depth and thorough investigation of an incident with serious outcomes or potential for serious outcomes?

The first type of investigation might be carried out by the line manager of the area; the second type often involves a team of investigators that might include a safety specialist, senior managers, a technical specialist and perhaps a worker representative.

Offshore investigating teams may also include installation specialists from services such as drilling, well services, maintenance, process, and deck crews. In the most serious or major cases, an inspector from the Health and Safety Executive (in the UK) or national safety enforcing agency may become involved and conduct or lead an investigation.

Step 1: Gathering Information

- Secure the scene as soon as possible to prevent it being altered.
- Collect witnesses' details quickly, before they start to move away. In some cases it may help to remove witnesses from the scene and ask them to wait in a separate area. If there are many witnesses it may be better to separate them from each other to prevent collusion or contamination of their testimony.
- Collect factual information from the scene and record it. This might be done by means of:
  - Photographs.
  - Sketches.
  - Measurements.
  - Videos.
  - Written descriptions of factors such as wind speed, temperature, etc.
  - Taking physical evidence.

  The investigator should come prepared with the appropriate equipment to record this information.

The investigator should collect factual information from the scene and record it

- Once the scene has been thoroughly examined, move on to the second source of information: witnesses.

Witnesses often provide crucial evidence about what occurred before, during and after incidents. They should be interviewed carefully to make sure that good quality evidence is gathered.

Topic Focus

Good witness interview technique requires that the interviewer should:

- Hold the interview in a quiet room or area free from distractions and interruptions.
- Introduce themselves and try to establish rapport with the witness using appropriate verbal and body language.
- Explain the purpose of the interview (perhaps emphasising that the interview is not about blaming people).
- Use open questions, such as those beginning with What? Why? Where? When? Who? How?, etc. that do not put words into the witnesses' mouths and do not allow them to answer with a "yes" or "no".
- Keep an open mind.
- Take notes so that the facts being discussed are not forgotten.
- Ask the witness to write and sign a statement to create a record of their testimony.
- Thank the witness for their help.

- Once witnesses have been interviewed, move on to the third source of information: documentation. Various documents may be examined during an accident investigation, such as:
  - Company policy.
  - Risk assessments.
  - Training records.
  - Safe systems of work.
  - Permits-to-work.
  - Maintenance records.
  - Disciplinary records.
  - Internal accident report forms.
  - Log book entries.
  - Computer printouts relevant to the situation.

Step 2: Analysing Information

The purpose here is to draw conclusions about the immediate and root causes of the incident.

Immediate causes are the unsafe acts and unsafe conditions that gave rise to the event itself. These will be the things that occurred at the time and place of the accident. For example, a worker slips on a puddle of oil spilt on the floor - immediate causes: the slip hazard (unsafe condition), the worker walking through it (unsafe act).

Underlying or root causes are the things that lie behind the immediate causes. Often root causes will be failures in the management system, such as:

- Failure to adequately supervise workers.
- Failure to provide appropriate PPE.
- Failure to provide adequate training.
- Lack of maintenance.
- Inadequate checking or inspections.
- Failure to carry out proper risk assessments.

Many of the accidents that happen in workplaces have one immediate cause and one underlying or root cause. The root cause gives rise to the immediate cause which in turn gives rise to the accident (rather like a row of dominoes falling; in fact this idea is often referred to as the **Domino Theory** of accident causation).

If that one root cause is identified and dealt with then the accident should not happen again. For example, if a worker twists their ankle in a pothole in the pavement then the obvious solution is to fill the pothole in. That deals with the immediate cause. It would also be worth asking how long the pothole had been there. If it had been there for a long time, why was it not spotted sooner? And if it had been spotted, why had it been left unrepaired with no interim measure being taken to protect people?

These questions might identify an underlying cause such as inadequate inspection and maintenance, or failure to put interim measures in place while waiting for maintenance work to be carried out. These root causes need to be dealt with if similar accidents are to be prevented in future.

In contrast to this single cause idea, some workplace accidents are complex and have multiple causes: there are several immediate causes for the accident and each of these has one or more underlying or root cause. This idea is usually referred to as **Multi-Causation Theory**.

Example 1 *- (onshore) a worker might be struck by a load being carried by a forklift truck.*

Immediate causes for such an accident might be:

- Failure to secure the load on the pallet.
- Poor road positioning of the truck close to a pedestrian exit.
- Aggressive braking by the truck driver.
- An inattentive pedestrian stepping out in front of the truck.

On investigation each of these immediate causes might have their own separate **root causes**, such as:

- No training for the driver, who is new to the workplace, has not worked with this type of load before and is unaware of the load securing technique required.
- Lack of segregation of pedestrian and traffic routes; no barriers and no markings to separate the two.
- Lack of proper driver induction into their new workplace so they are unaware of the layout and position of pedestrian exits, etc.
- Poor maintenance of the truck.
- No refresher training for existing staff, meaning that experienced staff have become complacent.

If there are multiple causes for the accident then it is important that each of these causes is identified during the investigation, otherwise incomplete remedial action will be taken and similar accidents may happen in the future.

Example 2 *- (onshore/offshore) a worker slips on a patch of spilt oil.*

Immediate causes:

- The slip hazard (unsafe condition).
- The worker walking through the oil (unsafe act).

With such a slip, the **root causes** might be a poorly maintained machine that has leaked oil onto the floor, and a poorly inspected and maintained workshop (where the oil leak was) with broken light fittings and inadequate lighting levels. Here, the worker might be blameless on the basis that, given those conditions, the incident was bound to happen eventually.

Example 3 - (offshore) a lifting sling breaks on the drilling deck.

Immediate causes:

- A damaged and worn sling (unsafe condition).
- A worker using the sling in poor condition (unsafe act).

With this offshore scenario, the **root causes** again fall to poorly maintained equipment, with a less than adequate inspection and sling replacement system, together, perhaps, with inadequate storage of lifting equipment, possibly exposing it to a harsh environment, being dropped on the deck, not hung up, etc. In this case there is some responsibility on the worker not to use a sling that is in poor condition, and this could be a result of lack of training in care and use of lifting equipment.

Consequences could have been many, including dropping equipment over the side into the sea, striking a worker (or workers) on the drilling rig beneath the sling, damage to plant on the drilling deck, etc.

Step 3: Identify Suitable Control Measures

Once the immediate and underlying causes of the accident are known, appropriate control measures can be identified. It is important that the correct control measures are established, otherwise time, money and effort will be wasted on inadequate and unnecessary measures that will not prevent similar occurrences in the future.

Control measures must be identified to remedy both the immediate and underlying causes. Immediate causes are usually easy to identify - if there is a spill of oil on the floor, clean it up; if the guard is missing from the machine, reattach it.

Underlying causes can be harder to determine because they reflect failure of the management system, but it is essential that the correct control measures to remedy the failure of the management system are identified because this will help prevent similar accidents occurring in similar circumstances across the entire organisation:

- Clean up the oil leaking out of the vehicle in the distribution depot but fail to deal with the underlying cause (lack of inspection and maintenance) and more leaks will occur which in turn will lead to more pedestrian slips (and perhaps, more alarming, vehicle skids).
- Clean up the oil leaking out of the vehicle and deal with the underlying cause (by introducing a proper inspection and maintenance system) and there is a good chance that most oil leaks will be prevented in the future for all vehicles in the fleet at all locations.

Perhaps the most important questions to ask when identifying control measures are:

- If this action is taken, will it prevent this same accident from happening in exactly the same way at this location?
- If this action is taken, will it prevent other similar types of accident from happening in similar locations in the future?

If the answer to both of these questions is "no", then you need to identify other control measures.

Step 4: Plan the Remedial Actions

An accident investigation should lead to corrective action being taken, in just the same way as a workplace inspection will. Remedial actions can be presented in an action plan:

Recommended action	Priority	Timescale	Responsible person
Introduce induction training for all new drivers	Medium	1 month	Warehouse manager
Introduce new inspection and maintenance system	High	1 week	Maintenance manager

When the action plan is being prepared, appropriate immediate and interim control measures must be given suitable priorities and timescales. Unsafe conditions must not be allowed to persist in the workplace. Dangerous practices and high risk activities must be dealt with immediately. This means that immediate action must be taken to remedy such circumstances when they are discovered. Machinery and equipment may have to be taken out of action, certain work activities suspended, and locations evacuated. These responses cannot be left until the investigation has been completed. They will have to be implemented immediately to ensure safety while the investigation is in progress.

There may be interim control measures that can be introduced in the short to medium term to allow work to proceed while longer-term solutions are pending. For example:

- Hearing protection might be introduced as a short-term control measure until the maintenance of a piece of machinery that is producing excessive noise has been completed.
- A perimeter guard might be fitted around an overheating machine that would ordinarily be protected with a fixed enclosed guard while new cooling units are sourced and delivered.

Underlying causes will often demand significant time, money and effort to remedy. It is essential, therefore, that the remedial actions that will have the greatest impact are prioritised and timetabled first. There may be actions that have to be taken (to address a management weakness or to achieve legal compliance) that will not be as effective in preventing future accidents. These actions should still be taken, but with a lower priority.

Cost of Remedial Actions

It is worth bearing in mind that there is always an element of cost involved when taking remedial action. Remember that there will not only be immediate costs, but also ongoing costs.

An example of this would be the simple matter of providing personal protective equipment. If a task required the wearing of respiratory protection, in the form of half-masks with replaceable filters, the initial cost would be for the masks and filters themselves, face-fit tests for users of the masks, storage facilities such as boxes, cases or cupboards, and the ongoing requirements for regular formal inspections of the masks by the users. Also ongoing would be the cost of replacing the filters and, eventually, the masks.

Where slings were not being cared for on an offshore installation, the remedial costs could be a supply of new slings, training for all users of lifting equipment, the introduction of a formal inspection, examination and testing programme, and new storage facilities away from harsh conditions. Ongoing costs would be regular supervision, maintenance of the storage facility, the regular inspection, examination and testing programme and occasional replacement of slings.

Importance of Learning from Major Incidents

It is vital that lessons are learned from all major incidents, as management, cultural and technical failures (i.e. process failures) must be understood so that incidents can be prevented from happening again.

There is much to be learned from investigations carried out into internal incidents, but the outcomes of other incidents also provide important information. An old saying in health and safety is: "There is no such thing as an accident – only a management failure". But remember that this statement is not laying the blame for incidents on managers. Instead, it suggests that health and safety was **managed** poorly overall by having inadequate safety systems in place.

For instance, an action as simple as misplacing a permit-to-work certificate was just one of the root causes of the Piper Alpha incident in the North Sea. There are other parallels that can be drawn from Piper Alpha, too, in management, cultural and technical failures that contributed to the loss of the oil rig and 167 lives.

The Piper Alpha Disaster

On the morning of 6th July 1988, as part of a maintenance programme, a gas pump pressure safety valve was removed from the processing area and, as the work could not be completed that day, a blanking plate was fitted over the end of the pipe where the pump had been removed. That evening, another pump failed. Without the engineers knowing (possibly due to the loss of a permit-to-work certificate) the safety valve was still off the process, and when they tried to start it the escaping gas exploded, penetrating the firewalls. Gas and oil pipes suffered in the heat and provided further fuel to the growing fire.

Although there was an automatic deluge sprinkler system in place which could pump hundreds of tons of sea water onto a fire, it was switched off because divers had been in the water, and it could only operate manually. It was not switched back on to automatic, and when it was needed it did not operate.

Twenty minutes after the initial explosion, large diameter gas pipes (up to 900mm) weakened and burst, releasing gas at two thousand pounds per square inch pressure, increasing the size of the fire.

A rescue boat arrived, but could not deploy its equipment quickly as it shut down when turned on, so this did not provide assistance quickly enough.

Many workers took refuge in the accommodation block but the coming and going and opening of doors allowed smoke in. The accommodation block was not smoke-proofed. By this time no one could get to the lifeboats, so many workers went to the extremities of the rig and jumped into the sea. Sixty-two people survived by taking this action. The accommodation block slipped into the sea, and a major part of the platform followed it.

The other 167 people on the rig lost their lives in the disaster. The whole incident occurred in just 22 minutes, the after-effects continuing into the night.

A Lesson Learned

This incident was instrumental in bringing about the introduction of the **Offshore Installations (Safety Case) Regulations 2005** in the UK (see later) and the regulatory control of offshore installations was taken over by the Health and Safety Executive (HSE) in 1991.

Some of the problems highlighted and lessons learned from the Piper Alpha disaster include:

- **Permit-to-Work Systems –** (paperwork systems used in high risk situations to control activities by closely monitoring the work carried out). The Piper Alpha systems had been relaxed, allowing less formal systems to operate, particularly relating to control of permits and communication at the shift hand-over. Proper adherence to the formal system and close control at the shift hand-over would have retained the hand-over permit and prevented the pump without the safety valve ever being started, so averting the disaster.

  Following Piper Alpha, the introduction of a permit co-ordinator and facilities for permitry were instigated. Control room competencies were also subject to review.

- **Safety Management** - vital in any industry, but more so in high-risk industries such as this, was shown (in Lord Cullen's report on the disaster) to be lacking. It was described as "superficial". Not all managers had adequate qualifications, and they tolerated poor practices and did not appear to audit systems properly. The delays in decision making allowed oil production to continue from other connected platforms while the fire raged on Piper Alpha.

More...

You can find out more about the Piper Alpha disaster by referring to:

The Public Enquiry into the Piper Alpha Disaster, Cullen, The Honourable Lord, The Stationery Office, 1990, ISBN 9780101131025

- **Design** – when the original oil exploration rig was adapted for gas processing, no changes were made to the firewalls. The original ones were capable of withstanding fire, but were not built to withstand an explosion, and they were breached in the gas explosions.

  Closely tied in with design was the number and size of pipelines on and attached to the platform, which helped to feed the fire.

- **Maintenance Systems** – closely associated with the permit-to-work system:
  - Proper maintenance procedures would have prevented the pump being started without the safety valve.
  - Closer control of the deluge system would have controlled its switching off while divers were in the water, and switching on when the area was clear.
  - Closer attention to audit and inspection reports would have meant that corroded sprinkler pipes and heads were repaired or replaced.

- **Safety Training –** some workers who ignored what they were taught survived, by not entering the accommodation block which eventually failed and sank into the sea, but in general training in emergency procedures on and off the platform was lacking. In particular, management leadership was especially inadequate in dealing with such emergencies.

- **Safety Audits –** as in all areas of offshore operations, audits are many and complex. The audits in Occidental Petroleum's North Sea field were in place and carried out on a regular basis, but they were not carried out satisfactorily. They identified few problems, possibly even overlooking issues such as corroding sprinkler deluge pipework. Some issues highlighted in audits were just ignored.

In the UK HSE publication HSG48, *Reducing Error and Influencing Behaviour*, the human contribution and other causes of the Piper Alpha disaster are summarised as:

> "Formal inquiry found a number of technical and organisational failures. Maintenance error that eventually led to the leak was the result of inexperience, poor maintenance procedures and poor learning by the organisation. There was a breakdown in communications and the permit-to-work system at shift changeover and safety procedures were not practised sufficiently."

Source: HSG48 Reducing Error and Influencing Behaviour (2nd ed.), HSE, 1999 (http://www.hse.gov.uk/pubns/priced/hsg48.pdf)

Toxic Gas Release, Bhopal, December 1985

The Bhopal incident changed the way that the chemical industry organises and manages the storage of chemical stocks, safety standards and safety procedures.

On 3rd/4th December 1985 a chemical release occurred at the Union Carbide India Ltd. plant in Bhopal, India, causing a massive toxic gas cloud. The process involved using methyl isocyanate (MIC), an extremely toxic chemical, to make Sevin, a pesticide. About 1,700 to 2,700 (possibly more) people were killed, 50,000 people were seriously affected, and 1,000,000 people were affected in some way by the chemical release. It was one of the worst industrial accidents in history.

The accident occurred when about 120 to 240 gallons of water were allowed to contaminate an MIC storage tank. The MIC hydrolysed, causing heat and pressure, which in turn caused the tank rupture disc to burst.

Equipment designed to handle an MIC release included a recirculating caustic soda scrubber tower and a flare system designed to moderate flows from process vents, but not to handle runaway reactions from storage. The design was based on the assumption that full cooling would be provided by the refrigeration system; at the time of the release the refrigeration had been turned off and the flare tower was shut down for repairs. A system of pressurised sprinklers that was supposed to form a water curtain over the escaping gas was deficient, as water pressure was too low for water to reach the height of the escaping gas.

Causes of the Accident

There were conflicting stories of how water got into the tank, including operator error, contamination and even sabotage.

The root cause of the accident appeared to be a management system that did not respond adequately to the potential hazards of MIC. There was probably a greater inventory of MIC than was needed. The main process expertise was in the United States and local management did not appear to have understood the process or the consequences of changes made, including plant design, maintenance and operations, back-up systems and community responsibility.

Buncefield, December 2005

The incident at Buncefield oil storage depot at Hemel Hempstead, Hertfordshire, England, happened during the night of 11th December 2005. A major fire occurred, caused by a series of explosions. At least one of the initial explosions was of massive proportions and fire engulfed a large proportion of the site. Over 40 people were injured but there were no fatalities. Significant damage occurred to both commercial and residential properties in the vicinity and a large area around the site was evacuated on the advice of the emergency services. The fire burned for several days, destroying most of the site and emitting large clouds of black smoke into the atmosphere.

The cause of the incident was the formation of a flammable mixture of petrol (gasoline) or similar spirit, and air that ignited, leading to the explosion and fire.

The filling of a tank (912) with petrol proceeded, and from 19.00 to 03.00 the tank became full and started to overflow. Evidence suggests that the protection system which should have automatically closed valves to prevent any more filling did not operate. From 05.20 pumping continued, causing fuel to cascade down the sides of the tank and through the air, leading to the rapid formation of a rich fuel/air mixture around the tank.

At 05.38 CCTV footage showed a vapour cloud of around 1m deep, which had increased to 2m deep by 05.46. By 05.50 the vapour cloud began flowing off site, and at 06.01 the first explosion occurred, followed by further explosions and a large fire that engulfed over 20 large storage tanks. The ignition point might have been a generator house and pump house in the vicinity.

Evidence suggests that a high-level switch, which should have detected that the tank was full and shut off the supply, failed to operate. The switch failure should have triggered an alarm, but that too appears to have failed.

The UK Health Protection Agency and Major Incident Investigation Board provided advice to prevent incidents such as this in the future. The primary need was for safety measures to be in place to prevent fuel from exiting the tanks in which it is stored. Added safety measures were needed for when fuel does escape, mainly to prevent it forming a flammable vapour and to stop pollutants poisoning the environment.

Deepwater Horizon Oil Spill, 2010

The Deepwater Horizon oil spill in the Gulf of Mexico near the Mississippi River Delta in the United States of America shows that lessons take some time to learn.

The Deepwater Horizon was a nine-year-old semi-submersible mobile offshore drilling platform, built by Hyundai Heavy Industries of Korea, owned by Transocean and operated under lease by British Petroleum (BP) from March 2008 (to September 2013).

In April 2010 drilling was in progress on an exploratory well at a water depth of approximately 5,000 feet (1,500m) in the Macondo Prospect in the Mississippi Canyon Block, about 41 miles off the Louisiana coast. The installation of production casing was under way, and when completed the well would have been tested for integrity and a cement plug put in place, reserving the well for future use.

On 20th April high pressure methane from the well escaped all the way up the drill column and expanded over the platform, igniting and causing an explosion, engulfing the platform in fire. The majority of workers from the platform escaped in lifeboats, but 11 were never found and presumed to have been killed in the explosion (there were two later oil-related deaths too).

The platform burned for around 36 hours, and then sank on 22nd April. The oil leak was discovered later that day when a floating oil slick spread where the rig had stood.

On 15th July the wellhead was capped, but not until it had released about 4.9 million barrels (205 million gallons) of crude oil. On 19th September the wellhead was finally sealed off. It has been estimated that around 53,000 barrels a day were escaping just before the wellhead was capped. The US Government announced that it was the 'worst environmental disaster the US has faced'.

The toxicity of the petroleum, oxygen depletion and the oil dispersant Corexit that was used at the location are thought to be the major causes of environmental damage.

Later investigations and witness testimony suggested that in a number of cases leading to the events of 20th April, BP appeared to have chosen riskier procedures possibly in order to save both time and money, and sometimes against the advice given by their own employees and contractors on the project. The cementing procedure was questioned, and it was suggested that the blowout preventer failed to fully engage, and there may have been problems with both the hydraulics and the controls. Another issue was that protective drilling mud was displaced with seawater just hours before the explosion occurred.

In the US Government Commission findings BP was accused of being responsible for nine faults, including:

- Failure to use a diagnostic tool to test the strength of the cement.
- Ignoring the pressure test that had failed.
- Not plugging the pipe with cement.

  (BP were not directly blamed for any of these events.)

The Commission's findings were that what was missing, and therefore needed, were:

- Better management of decision-making processes.
- Better communication between the company and its contractors.
- Effective training of key engineering and rig personnel.

Safety Culture

All groups of people (such as factory-workers, office staff, the crew of a ship or the workforce on an oil rig) develop a "safety culture".

Jargon Buster

Safety culture

A system of shared values and beliefs about the importance of health and safety in the workplace, and the associated way of behaving.

An organisation with a good health and safety culture will have high regard for health and safety, and good perception of risk will be shared by all workers, with employees adopting the same positive attitudes – that health and safety is their problem and they will deal with it appropriately.

This positive culture will therefore influence how all individuals in the workforce handle new events (such as emergencies) and make decisions during those events. The workforce will not put operational requirements before health and safety. A good safety culture requires effective safety management systems and management commitment.

The failures identified in the Piper Alpha disaster included faults in organisational structures and procedures (culture) and identified them as equally important contributory factors as the individual human and technical failures.

Revision Questions

1. What is the prime purpose of an accident investigation?
2. What are the four elements of the investigation process?
3. Identify the categories of staff who might be considered useful members of an internal accident investigation team.
4. List the types of documentation which might be consulted during an accident investigation.
5. What are the two categories of immediate cause of accidents/incidents?
6. An employee has been hit by a reversing vehicle in a loading bay. List possible immediate causes and root causes.

(Suggested Answers are at the end of Unit IOG1.)

Hazards Inherent in Oil and Gas

Key Information

- It is important to understand the meaning and relevance of specific terms when discussing hazards inherent in the oil and gas industry: flash point; vapour density and pressure; flammability and flammable limits; toxicity; skin irritant; and carcinogenic properties.
- The properties and hazards associated with different gases, particularly those relating to: hydrogen, methane, liquefied petroleum gas (LPG), liquefied natural gas (LNG), nitrogen, hydrogen sulphide, and oxygen, are essential knowledge for those working in the industry.
- Associated products (anti-foam and anti-wetting agents; micro-biocides; corrosion treatments; refrigerants; water and steam) have their own properties, hazards and control measures.

Terminology

Characteristics of fires and explosions associated with gas and oil processes make reference to various technical features, which you need to understand.

Flash Point

Flash point is the lowest temperature at which sufficient vapour is given off to "flash", i.e. ignite momentarily (not continue to burn), when a source of ignition is applied to that vapour.

Substances having a flash point below ambient temperature will pose a hazard as they will be producing flammable vapour. Gases will always give flammable vapours and therefore have very low flash points, well below their boiling point.

Abel apparatus is just one method used to give a simple test, applying an igniter into a vessel containing the substance which is gradually warmed, noting at which point its vapour ignites momentarily.

A test can be applied to base fluids being considered for use in an oil mud or a synthetic mud, or to any flammable liquid to determine at what temperature an explosion hazard exists. This is an API (American Petroleum Institute) and ASTM (American Society for Testing Materials) standard test.

In the USA they use a precise definition of 'flammable liquid' as one with a flash point below 1000° Fahrenheit.

Vapour Density

Vapour is the dispersion of molecules of a substance in air that is liquid or solid in its normal state, e.g. water vapour, benzene vapour. Vapour density expresses the mass per unit volume, i.e. its weight. It is measured relative to hydrogen (in the USA air is used).

Vapour density has implications in container storage and the safety of personnel, in that if a container can release a dense gas (heavier than air) its vapours will sink. If they are flammable vapours, they will collect at low level until they reach a concentration sufficient for ignition to occur. Even if the vapours are non-flammable, they can accumulate in a lower floor or bottom of a confined space and displace air, with the hazard of asphyxiation to persons entering that space. This is particularly important where hydrogen sulphide (H_2S) is present and a number of deaths have occurred where gas has travelled or settled in trenches or pits.

Vapour Pressure

Vapour pressure is the pressure exerted by a vapour in equilibrium with its liquid (or solid) state.

A liquid standing in a sealed container is a dynamic system, and some liquid molecules evaporate to form a vapour, while some molecules of vapour condense to form a liquid, i.e. equilibrium. The vapour, as would any gas, exerts pressure, and this pressure at equilibrium is the vapour pressure.

Classification of Flammability

Flammable substances fall into three classifications:

Flammable Classification	Flash Point
Extremely Flammable	Below 0°C
Highly Flammable	0° – 21°C
Flammable	22° – 55°C

This indicates that the **higher** the flash point of a substance, the **safer** it is in terms of flammability.

Flash Points of Some Common Solvents

Determined by Abel Closed Cup method

Solvent	Flash Point
Butanone (methyl ethyl ketone (MEK))	−7°C
Diesel oil	40°C (approx)
Ethyl ethanoate (ethyl acetate)	−4°C
Ethoxyethane (diethyl ether)	−40°C
Methylated spirit	10°C
Methylbenzene (toluene)	4°C
Petrol (benzene, gasoline)	−40°C (approx)
Phenylethene (styrene)	32°C
Propanone (acetone)	−17°C

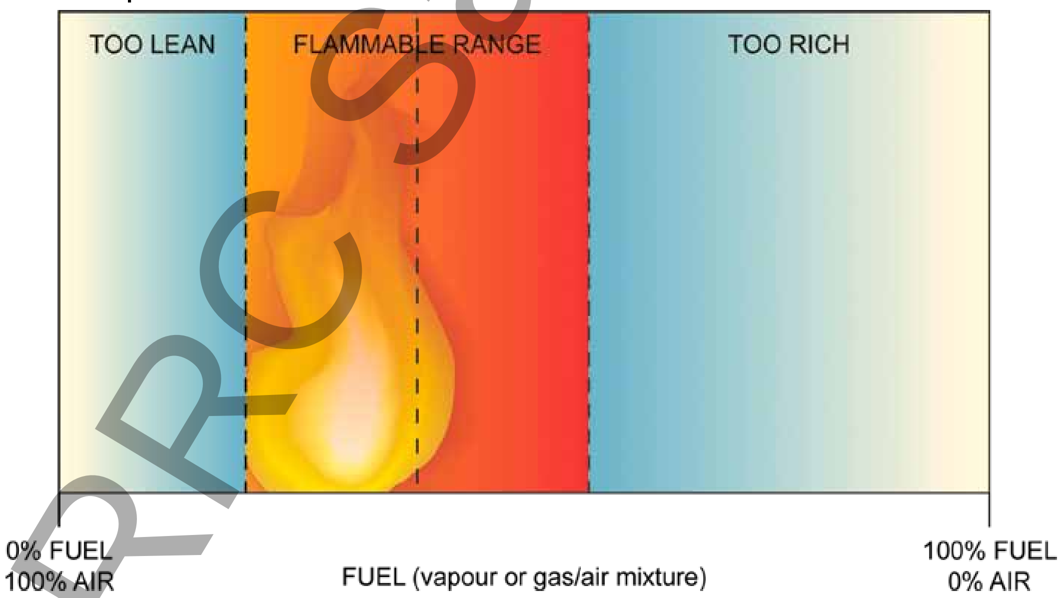
This indicates that fuel such as petrol (gasoline) is far more dangerous if spilled than diesel oil, because the vapours of the petrol will ignite from any ignition source, whereas diesel will not. Think of such a spillage within the bund of a tank. Substances with very low flash points are very volatile. Flash point tests can be applied to any liquids, not just hydrocarbons. There are apparatus other than the Abel method used to determine flash point, such as Pensky-Martens.

Flammable Limits

The **Lower Flammable Limit (LFL)** is the point where there is insufficient fuel to sustain combustion because it has become over-diluted with oxygen/air.

The **Upper Flammable Limit (UFL)** is where there is too much fuel for combustion to occur (not enough oxygen/air dilution).

In relation to explosives, these are known as the upper and lower **explosive limits**.



An illustration of flammable limits

100% ← air or oxygen → 0%

Lower Flammable Limit **Upper Flammable Limit**

In pure oxygen or oxygen-enriched air, the limits become wider than they are for air, so it is more likely that a mixture of gas or vapour here will be within the flammable range and fires will be more difficult to extinguish.

Conversely, if the air or oxygen is diluted ("inerted") with an inert gas (nitrogen or carbon dioxide), the limits of flammability become narrower until they converge so that there is no flammable range. Such dilution would typically reduce oxygen content to 8% - 10% (the same limit below which an atmosphere would be irrespirable and unable to support life).

In the practical situation of a leak involving petrol (gasoline), dispersal and natural dilution in still air would reduce the vapour content below the lower flammable limit at a distance of about 12m from the leak; this is known as the **safe dilution point** and gives an indication of the size of the zone which would be needed ("exclusion zone") to control sources of ignition in order to prevent a fire.

Flammable limits in air

Fuel	Physical state	Lower % limit	Upper % limit
Hydrogen	Gas	4.9	75
Carbon monoxide	Gas	12.5	74
Methane	Gas	5	15
Propane	Gas	2.5	9.5
Butane	Gas	2	8.5
Ethylene (ethane)	Gas	3	32
Acetylene (ethyne)	Gas	2.5	80
Ethyl alcohol (ethanol)	Liquid	4	19
Carbon disulphide	Liquid	1.3	50
Petrol (gasoline)	Liquid	1.4	7.5
Paraffin (kerosene)	Liquid	0.7	5

Explosive Atmosphere Situations

Where there is a gas/air mixture within flammable limits, especially in a confined space, there is an explosion danger; a chance ignition may initiate a reaction, which will propagate through the mixture.

Explosions have occurred in the following circumstances:

- During hot work, i.e. welding, grinding.
- Where naked flames have occurred.
- Where metal tools have created sparks.
- Where electrical equipment has created sparks.
- Where static electricity has generated sparks.

Toxicity

Toxicity is the ability of a chemical molecule to cause injury after it has reached a susceptible site in or on the body, and also applies to the quantitative study of the body's response to toxic substances.

Chemicals are classified according to their toxicity (**health effects**), which apply to all their forms (liquids, solids, gas, etc.) generally as:

- **Very toxic** – substances and preparations which in very small quantities can cause death or acute or chronic damage to health if inhaled, swallowed or absorbed through the skin.

- **Toxic** – substances or preparations which in **small quantities** can cause death or acute or chronic damage to health when inhaled, swallowed or absorbed through the skin.
- **Harmful** – substances or preparations which cause death or acute or chronic damage to health when inhaled, swallowed or absorbed through the skin.
- **Corrosive** – substances and preparations which may, on contact with living tissues, **destroy** them.
- **Irritant** – non-corrosive substances and preparations which through immediate, prolonged or repeated contact with the skin or mucous membrane, may cause inflammation.
- **Sensitising** – substances and preparations which, if they are inhaled or if they penetrate the skin, are capable of eliciting a reaction by **hyper- sensitisation** such that on further exposure to it characteristic adverse effects are produced. Such substances will be recognised as sensitising by inhalation or sensitising by skin contact.
- **Carcinogenic** – substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce **cancer** or increase its incidence.
- **Mutagenic** – substances and preparations which, if they are inhaled, ingested or if they penetrate the skin, may induce **heritable genetic defects** or increase their incidence.
- **Toxic for reproduction** – substances and preparations which, if they are inhaled, ingested or if they penetrate the skin, may produce or increase the incidence of **non-heritable adverse effects** in the progeny and/or an impairment of male or female reproductive functions or capacity.

Properties and Hazards of Gases

Gases are used and created in the production and processing of oil and gas, so we must look at the properties of gases and the hazards associated with them.

- **Hydrogen** – widely used in petroleum refining as a catalyst regenerator, it is a highly flammable and explosive gas which forms ignitable mixtures in air over a very wide range of concentrations (between 4.9% - 75%). It is colourless and odourless and very light, and explosive mixtures form rapidly. It can be easily ignited by low-energy sparks. It is not a toxic gas, but can asphyxiate at high concentrations. It can react vigorously with oxidising agents.
- **Methane** – also known as methyl hydride, marsh gas and fire damp, it is used in the manufacture of hydrocarbons and is the main fuel constituent of natural gas. It is highly flammable and explosive, and forms an ignitable mixture with air over a wide range of concentrations (5% - 15%). Again, it is very light and may collect beneath structures such as roofs, ceilings and platforms creating pockets of explosive mixtures. Methane is a simple asphyxiant, and an odorising agent is usually added to it.
- **Liquefied Petroleum Gas (LPG) (Propane/ Butane)** – gas at normal temperature and pressure, but readily liquefied under pressure. It is a feedstock for chemical petroleum manufacture, as well as a fuel gas for heating, cooking, lighting, and operating internal combustion engines. It is also used as a fuel gas in welding and cutting, and in the manufacture of high-octane liquid fuels. LPG is highly flammable and being denser than air collects at low level and readily forms an explosive mixture. In some cases weak concentrations can be ignited with the flame readily flashing back to the source of a leak. Inhalation can lead to drowsiness, and exposure to moderately high concentrations can prove serious. It is colourless and odourless, and has an odorising agent added except where used in a chemical reaction. It is an asphyxiant and may react explosively with chlorine.

  The dangers of LPG lie with its flammability and explosive properties, and the fact that it is stored under great pressure, and hence very low temperatures, to retain its liquid state. On release, LPG reverts to its gaseous state, the gas becoming around 250 times the volume than when stored in liquefied form.

  While the main risks are from fire and explosion, the fact that the gas is heavier than air is of significance to persons working in low-lying or confined areas (such as excavations, pits, etc.) due its asphyxiating properties. For persons handling cylinders, pipework and connections for LPG systems there is a risk of frost burns due to the low temperatures, and cylinders pose a manual handling risk.
- **Liquefied Natural Gas (LNG)** – as the name suggests, a liquefied methane (North Sea gas has 93.7% methane) used as a fuel gas for heating, cooking, etc. It is used in the manufacture of acetylene, methanol, hydrogen and carbon black. From the liquefied state it easily vaporises forming a highly flammable odourless gas, again having an odorising agent added. It will form an explosive mixture with air. Vapour can be ignited some distance away from a leak and the flame will spread back to the source. It is a simple asphyxiant, and non-toxic as a gas.

  Contact with its liquefied form will cause frostbite; LNG is cold (boiling at -161°C). Its volume increases 630 times on vaporisation. Low temperature tolerant metals and materials are used during liquefaction, transfer and storage. Industry best practice is applied in the design of LNG plant, and it is usually stored as a liquid at atmospheric pressure in special steel inner tanks with outer concrete shells with no bottom connections.

Pressurised storage and transport is not used, reducing the dangers of catastrophic vessel failure with results such as boiling liquid expanding vapour explosions (BLEVEs). The unintentional release of LNG and its dispersion will create fire and explosion hazards such as pool fire spread, evaporation and pool fires.

- **Nitrogen** – a common odourless, colourless gas, tasteless and non-flammable, making up naturally 78% of the Earth's atmosphere. Industrial nitrogen is produced by the fractional distillation of air. Its chemical uses include it as a component in the manufacture of ammonia, which is then used as a fertiliser and to produce nitric acid. In industry it is commonly used to "inert" flammable atmospheres, as a "cover" on flammable and explosive substances (a gas layer lying above the liquid in a tank) and to inflate tyres, used in a form often called OFN – oxygen-free nitrogen.

  In addition to inerting and cover capabilities, nitrogen is used for pipe freezing and pipeline purging, and offshore for a number of well services operations, such as drill stem testing or perforating operations, nitrogen lift, etc.

  Nitrogen in the blood causes reactions with haemoglobin decreasing the oxygen-carrying capacity of the blood.

- **Hydrogen Sulphide** – a colourless flammable gas that forms explosive mixtures with air over a wide range of concentrations (4% - 46%). It is denser than air and will accumulate in low level areas, and can travel long distances to an ignition source and flash back. Hydrogen sulphide is toxic, and will irritate the eyes, skin and respiratory tract and can lead to respiratory paralysis. It will rapidly deaden the sense of smell so its offensive odour of rotten eggs cannot be relied on to detect it. It often occurs in natural areas such as swamps, ponds and lagoons and where there is rotting vegetable matter. It is used in the manufacture of elementary sulphur and purification of acids.

  The effects of hydrogen sulphide depend on duration of exposure, frequency of exposure and the intensity (concentration of the gas), as well as the susceptibility of the person exposed.

  Since it is present in some subsurface formations, drilling and other operational crews must be prepared to use detection equipment, personal protective equipment (particularly respiratory protective equipment) and require adequate training backed up by contingency procedures in case of over-exposure in hydrogen sulphide prone areas. It will enter drilling mud from subsurface formations, can be generated by sulphate-reducing bacteria in stored muds, and formed in concrete leg platforms below the gas-tight floor.

- **Oxygen** – a colourless, odourless gas that is often regarded as the most essential on the planet, and one of the most dangerous. Oxygen enrichment can lead to fires and explosion, and will react violently with oils and greases. It is used with fuel gases in welding and burning to intensify combustion.

  Oxygen is non-flammable, but it will support and encourage the combustion of oxidisable materials, combustible materials becoming more easily ignited in an oxygen-enriched atmosphere. They burn far more rapidly with near explosive violence.

  Oxygen is sometimes used offshore to detect and quantify the flow of water in or around a borehole based on oxygen activation.

  On 23rd September 1976 a fire broke out on **HMS Glasgow** in the Neptune Shipyard of Swan Hunter Shipbuilders at Newcastle upon Tyne. The fierce, rapid fire caused the death of eight workers on the ship; others, including fire-fighters, were overcome by smoke and needed hospital treatment.

  Below decks in the work area, lighting cigarettes and experiencing rapid-burning did not alert the men to what they were experiencing – they did not recognise an oxygen-enriched atmosphere. It was not the cigarettes, but the higher energy of the welding flames and electric arcs that ignited the atmosphere. Oxygen can easily be absorbed into clothing and under these conditions a simple spark or other small source of ignition can result in flash-burning. The higher the oxygen levels in air, the more the temperature at which other substances will ignite will fall.

Properties and Hazards of Associated Products and Control Measures

Additives

In addition to the gases we have looked at, there are many associated products and materials used in oil and gas processing that can cause harm in some way, including:

- **Anti-foaming agents** (defoamers) - chemical additives that reduce and hinder the formation of foam in industrial process liquids.

  They are used in various industrial processes and products, including industrial wastewater treatment, oil drilling, hydraulics, cutting oils, food processing, wood pulp and paper manufacture.

  Anti-foaming agents are normally used to increase speed and reduce problems with surface foam and entrapped or entrained air in system fluids. They are insoluble in the foaming medium and have surface-active properties, being of low viscosity and capable of spreading quickly over foaming surfaces.

They rupture air bubbles and cause the breakdown of surface foam, forming bubbles into a mass and causing larger bubbles to go to the surface of the liquid more quickly.

Anti-foam agents are used in process and cooling liquids to reduce problems caused by foam and dissolved or trapped air, such as:

- Cavitation reducing pump efficiency (and creating noise).
- Reduction in the capacity of pumps and storage tanks.
- Bacterial growth in the fluids.
- Dirt and debris formation and surface flotation.
- Reduction in the effectiveness of the fluids in use.
- Longer downtime for cleaning and maintenance.
- Clogging of filtration equipment.
- Shorter fluid replenishment times and added costs.

Anti-foam agents come in many chemical bases such as oil, powder, water, silicone and glycol.

- **Anti-wetting agents** – generally coatings intended to place a waterproof barrier (in this case a hydrophobic surface) between the surface of a material (usually metal and wood) and water, such as the sea and wet weather. Water is also a source of failure in electrical equipment in harsh oil and gas process environments. Even when totally immersed in sea water, good anti-wetting agents will create such a super-hydrophobic surface on structures and components that little, if any, water can get through to the surface. Although not directly treating corrodible surfaces, anti-wetting agents in this respect provide good anti-corrosive protection.
- **Micro-biocides** – anti-bacterial treatments added to industrial fluids, usually cooling and process water, especially in standing supplies such as ponds, lagoons, reservoirs, etc., and static water-storage facilities. Some applications may include:
  - Oil-system biocides – control bacterial population growth of aerobic and anaerobic bacteria in oil-production and water-injection systems.
  - Water injection system biocides – maintain control of bacteria in water injection systems especially where de-aerator towers are used.
  - Fuel preserving biocides – broad spectrum biocides and fungicidal treatments added to hydrocarbon fuel systems such as kerosene, diesel and petrol (gasoline). They deter fungal growth in water that is present in all fuels. Without treatment, fuel and additives will degrade, organic acids can be produced that corrode fuel systems and components, and slime can be generated that will clog lines and filters.
  - Water system biocides - treat all types of salt and freshwater systems and process brines to kill all bacterial growths. It is important that such treatments are safe to be discharged into the sea.
  - Special biocides - can include those developed not only for water and water injection systems, but also to reduce sulphate-reducing bacteria in drilling and process platform structures (e.g. platform legs) and pipelines.
- **Corrosion preventatives** – additives for industrial fluids to delay or prevent the formation of corrosion within fuel systems and process pipelines. They are also used on structures and system components in the form of anti-wetting agents (see earlier) that provide a waterproof coating. Often sacrificial coatings or materials (such as zinc) are used, but have a limited life.
- **Refrigerants** – substances used in a heat cycle usually including a phase-change from a gas to a liquid. Propane is a common refrigerant, as CFCs are being replaced. Other applications may use ammonia, sulphur dioxide and methane.

  Propane is commonly used in natural gas processing to give the right chilling in condensing heavy components for a rich gas, often using one, two or three-stage compression systems.

Hazards and Risk Controls

- **Hazards**
  - Those associated with the type and form the agent takes (liquid, powder, etc.).
  - Being of some chemical hazard (toxic, harmful, irritant, etc.).
  - Can be absorbed through inhalation, ingestion, skin contact, etc.
- **Control Measures**
  - Risk assessment for use of hazardous substances.
  - Automated dosing systems instead of hand-dosing.
  - Safe storage and handling procedures.
  - PPE suitable for the nature and extent of the hazard (e.g. waterproof/chemical-resistant clothing, goggles, respiratory protective equipment).

Associated Products

- **Water and steam –** used extensively in processes such as system cooling, lubrication (drilling muds) and sea water for fire deluge

  Water flooding and steam flooding are frequently used as advanced recovery methods to increase reservoir pressure to "push" hydrocarbons out. This usually requires the use of injection wells and is often used to deal with problems such as loss of reservoir pressure or high oil viscosity. This can increase the amount of oil ultimately recoverable.

A method of thermal recovery is often used in which a well is injected with steam which is then put back in production. Cyclic steam injection is used extensively in heavy-oil reservoirs, tar sands, and in some cases to improve injectivity before steam flood or in situ combustion operations. Steam is used in re-boilers onshore.

- **Hazards** associated with high pressure and high temperature water and steam are pressure injection of fluids into the body, as well as severe steam burns. Exposure to inhalation of high concentrations of steam can cause burning in the lungs and even asphyxiation.
- **Safe handling** procedures must be in place, together with the use of appropriate water and heat-proof clothing to resist steam burns.

- **Mercaptans** – a group of sulphur-containing organic chemical substances, with offensive odours such as rotting cabbage, which make them very noticeable in the air. They are sometimes used as an odorising agent in natural gas to make it detectable.

  Gas and oil streams coming from well heads contain sour gas (the "rotten eggs" of hydrogen sulphide), and inlet oil and gas will also contain mercaptans, which are offensive in odour. Methyl and ethyl mercaptan have higher odour detectibility as they are more volatile.

  Processes are in place in oil refineries and natural gas processing plants that remove hydrogen sulphide and mercaptans - known as "sweeteners", they remove the sour, foul odours.

  Leaks or discharges of mercaptans are easily detected, and lead to headaches and nausea when inhaled, accompanied by vomiting. Coughing, irritation of the lungs and inflammation of the eyes may result. Very high concentrations may lead to breathing difficulties and cyanosis (turning blue), loss of consciousness and muscle spasms. Appropriate respiratory protective equipment (RPE) should be worn where potentially harmful levels may be present.

- **Drilling muds** – (also known as drilling fluids), are used in drilling deep holes, as in oil and gas extraction. The mud is often an integral part of the process, serving a number of functions, but particularly as a lubricant. Drilling muds cut down the friction experienced, lower the heat and reduce the chances of friction-related complications. The mud also acts as a carrier for the materials through which drilling takes place, suspending it and carrying it up to the surface. Different muds will be used in different circumstances, based on their viscosity and density. Muds can be water (aqueous) based, non-aqueous based, such as oil-based muds, or gaseous fluids (gas based), and may contain minerals or be totally synthetic in nature.

  - **Aqueous-based muds** start with water (sometimes working just with water) then clays (e.g. bentonite or "gel") and other chemicals (e.g. potassium formate) are incorporated, to create a blend resembling a dark chocolate liquid. The fluid flows freely while being pumped and when static "gels" and resists flow, until being pumped again.
  - **Oil-based muds** often use diesel fuel as their base, which gives better lubrication than aqueous muds, cleans more easily (within the core) and has less viscosity.
  - **Gaseous-based muds** often use compressed air alone or air/water mixtures, sometimes having polymer-type chemicals added (such as anti-foaming agents).
  - **Synthetic drilling-fluids** are more often used offshore as they have all the properties of oil-based mud but less toxicity (e.g. than from diesel fumes).
  - Hazards associated with drilling muds include contact with the additives (e.g. diesel oil and its fumes, anti-foaming agents), and the natural gases and flammable materials that can be returned to the drilling work areas, leading to a fire or explosion risk, especially around shale shaker/conveyor areas, before being returned to the mud pits.
  - Suitable controls will include fire safety precautions, and appropriate PPE to prevent unnecessary skin contact with the muds.

- **Sludges** – (drilling wastes) including **low specific activity** (LSA) sludges. Depending on the nature of the base (the geological formation) being drilled for oil and gas, there may be naturally-occurring radionuclides, such as uranium and thorium, (referred to as NORM – Naturally Occurring Radioactive Materials). LSA are routinely found in both onshore and offshore activities.

  They will be contained in the brine solution (formation water) that is around the pockets of oil and gas, and will be contained within the drilling content and returned to the surface. On the surface, the brine is separated from the oil and gas, which is referred to as "produced water".

  The radioactive decay products (usually radium) may dissolve in the brine, and can stay in solution or settle out to form sludges in tanks and mud pits, or form mineral scale inside pipelines and drilling components.

Radiation levels will vary greatly depending on the geological nature of the site, but monitoring will be required in settling-out areas on the surface to ensure safety.

LSA scale in connection with oil production is mainly composed of precipitated calcium carbonate or barium sulphate (barite) which co-precipitate with naturally-occurring radium leached out of the reservoir rock. Some levels of strontium may also be involved.

The activity of LSA scale depends on how much radium is present, and the content of radium will vary with the type of rock and its content of uranium and thorium. LSA scale is not easily soluble, and its removal from production equipment requires the use of specialist dispersal chemicals or high pressure water flushing. It is important that all personnel working with LSA scale protect themselves and others from contact with radioactive materials. Extra care must be taken to avoid inhalation or ingestion of these materials as alpha radiation has a long half-life and will take a very long term to be removed from the body.

LSA sludges vary from standard sludge, through soft, easily removed scales, to very hard and tenacious scales, and the levels of radio activity will vary from just above "background" to levels requiring restricted, controlled areas and classified workers. LSA scale is classed as a radioactive substance and its handling and disposal could present occupational health and hygiene risks. Operators must develop and put in place effective procedures that recognise the hazards, protect workers from harmful exposure, minimise interference with the environment and ensure that national and international regulations are followed.

In gas production areas LSA can be in the form of lead-scale. Pyrophoric iron is often found in sludges offshore and onshore and needs special control measures for its disposal because of its properties.

In oil and gas production LSA scale is typically found in:

- The production well.
- Safety valves.
- Well heads.
- Production manifolds.
- Inside separators.
- Water separators.

Revision Questions

7. Explain Lower and Upper Flammability Limits.
8. Explain the meaning of the classification 'carcinogenic'.
9. What are the main dangers associated with LPG?
10. What is the purpose of anti-foaming agents?
11. What term is applied to drilling wastes that contain naturally occurring radioactive materials (NORMs)?

(Suggested Answers are at the end of Unit IOG1.)

Risk Management Techniques Used in the Oil and Gas Industries

Key Information

- There are many risk assessment methods, such as the basic "Five Steps" approach, and qualitative and quantified risk assessment.
- Risk management techniques and tools can be applied in process safety risk identification and assessment, and models applied to aid risk control, such as HAZOP, HAZID and FMEA.

Purposes and Uses of Risk Assessment Techniques

In their publication "*Five Steps to Risk Assessment*" (INDG 163(Rev 2)) the UK Health and Safety Executive (HSE) describe risk assessment as "*simply a careful examination of what, in your work, could cause harm to people, so that you can weigh up whether you have taken enough precautions or should do more to prevent harm*".

Source: INDG163(rev2) Five Steps to Risk Assessment, HSE, 2006 (http://www.hse.gov.uk/pubns/indg163.pdf)

The five steps described in this system are:

This method of risk assessment works well for less complex risks, and is suitable for most organisations where ranking of the risks is not a major requirement. But when the more complex risks associated with oil and gas production and processing have to be assessed, the technique used is likely to require far more depth and technical insight.

The UK **Offshore Installations (Safety Cases) Regulations 2005** require that:

- All hazards with the potential to cause a major accident have been identified.
- All major accident risks have been evaluated and measures have been, or will be, taken to control the major accident risks to ensure compliance with the relevant statutory provisions, i.e. a **compliance demonstration**.

The application of risk assessment should be proportionate to the magnitude of the risk. Because of the higher levels of risk in the oil and gas industries, we need to go further than the Five Steps approach and consider qualitative and quantified risk assessment techniques, the main objectives here being to identify **and rank** the risks and to examine risk reduction measures to determine which to use.

Qualitative and Quantified Risk Assessment

The risk assessment technique used should be able to rank the risks (risk ranking is not a significant detail of the Five Steps approach) so that the right reduction methods can be applied, and would probably progress in the following way:

- **Qualitative (Q)** – using qualitative methods to determine frequency and severity.
- **Semi-Qualitative (SQ)** – where frequency and severity are approximately quantified within ranges.
- **Quantified Risk Assessment (QRA)** – where full quantification is demonstrated.

As the assessment process moves through the stages, the level of detail will increase proportionate to the risk, taking into account the level of estimated risk within limits of tolerability, and the complexity of deciding on what (more) needs to be done to reduce the risk.

Determining the Right Method of Risk Assessment

Risk assessment is used to enable us to decide upon appropriate risk controls so assessors should be suitably senior, qualified and competent. Start with a qualitative model and enlarge the model (moving to SQ and QRA) as needed:

- **Qualitative (Q):**
  - If it **is** adequate for deciding on appropriate controls, use this method to assess and record the findings and recommendations.
  - If it is **not** adequate, use SQ.
- **Semi-Quantitative (SQ):**
  - If this (using more depth than Q) **is** adequate for deciding upon appropriate controls, use SQ. Record the findings and recommendations.
  - If it is **not** adequate, first increase the depth of modelling of the risk assessment and see if it now meets requirements. If it does, record the findings and recommendations.
  - If it is not, **use QRA**.
- **Quantified Risk Assessment (QRA):**
  - If it is adequate, use QRA.
  - If it is not, increase the depth of the risk assessment model until it answers all questions. Record findings and recommendations.

More...

In their *Offshore Information Sheet* No 3/2006, the UK HSE give more industry specific guidance on how to determine which risk assessment method is appropriate.

You can access this document at:

http://www.hse.gov.uk

The Starting Point Approach

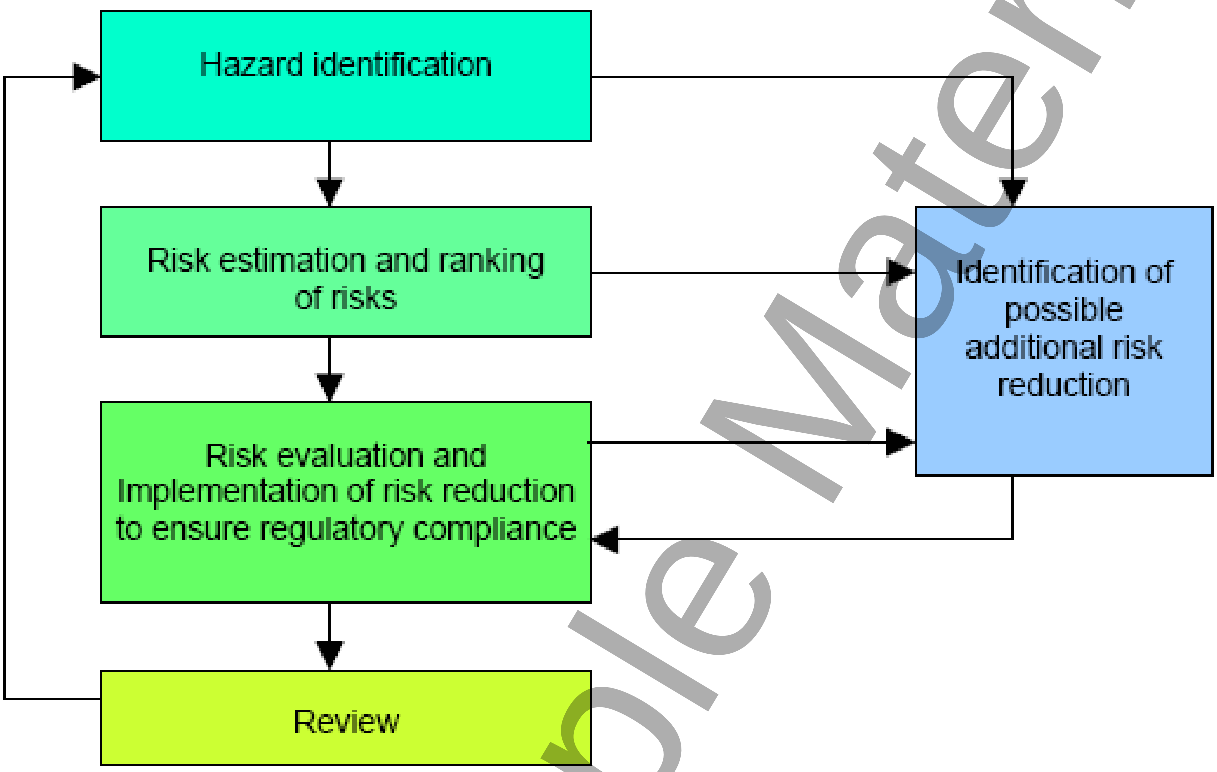
Even using this method, it may still be necessary to upgrade the approach if it proves to be not detailed enough to determine suitable risk controls.

Examples of starting points could be:

- Large integrated platforms or nodal platforms in the North Sea are likely to have a combination of complexity and risk level requiring QRA.
- For less complex installations and those with smaller workforces, e.g. drilling installations, normally unattended installations (NIUs), etc. SQ could be suitable. In these cases, good practice procedures will be largely relied upon to control such risks as transporting workers between installations (e.g. helicopter transfers).
- In cases where there are clear standards and benchmarks for design and risk reduction, Q will often be sufficient.
- For some stages of the lifecycle, where hazard identification can lead directly into specification of good practice risk reduction measures, e.g. combined operations and decommissioning, Q or SQ may often be sufficient.

Hazard Identification

This is the underlying process of risk assessment and must be carried out thoroughly in all cases and models used. The main stages in assessment are:



Source: Offshore Information Sheet No.3/2006, Guidance on Risk Assessment for Offshore Installations, HSE, 2006 (http://www.hse.gov.uk/offshore/sheet32006.pdf)

Risk Estimation and Ranking of Risks

Here, the likelihood (or frequency) of an adverse event, together with its consequences (severity) are estimated, the level of detail increasing as the model moves from Q, through SQ to QRA. A matrix is used (either 3 × 3 or (better) 5 × 5) to indicate risk levels - see following figure.

LIKELIHOOD → / SEVERITY ↓	VERY UNLIKELY	UNLIKELY (MAY HAPPEN)	LIKELY	VERY LIKELY	CERTAIN
FATALITY	5	10	15	20	25
MAJOR INJURY	4	8	12	16	20
OVER 3-DAY INJURY	3	6	9	12	15
FIRST AID INJURY	2	4	6	8	10
MINOR INJURY	1	2	3	4	5

This now allows us to establish what more (if anything) needs to be done to reduce the risk. This can be determined, in simplest form, as:

1-4	**LOW RISK**	Maintain current levels of control.
5-10	**MEDIUM RISK**	Some further controls should be planned to reduce the risk further.
12-25	**HIGH RISK**	At this level work must STOP (or not begin if in planning stage) until further controls reduce the risk.

Do not forget the importance of the risk control measures already in place, as existing controls can be modified, rather than introducing new ones.

Also, different aspects of a single risk can be affected by different situations, and one example given by the UK HSE (*Offshore Information Sheet No 3/2006*) is the consideration of which stages of a scenario dominates its risk. In an emergency situation, for instance, would fatalities be immediate, be caused by escalation, or would they occur during escape, evacuation and rescue?

How Risk Management Tools are Applied

The following is an extract from the UK HSE publication *Managing for Heath and Safety* with particular application to major hazard industries such as oil and gas processing.

"Industries where low frequency, high impact incidents would have catastrophic consequences must be properly managed, to ensure that the hazards are kept firmly in check. There should be illustrated and demonstrated risk reduction. Strong health and safety leadership, coupled with robust safety management systems, will ensure that best practice is shared and learning is disseminated from previous incidents. For major hazard sites, leadership on the key area of process safety is core. Board level involvement and competence are essential; constant and active engagement in and promotion of process safety by the leadership sets a positive safety culture."

Source: Managing for Health and Safety, HSE, 2010 (http://www.hse.gov.uk/managing/regulators/regulators.pdf)

Risk management does what is says – manages risks (not just assessing them), and a standard "tool" used throughout health and safety is that demonstrated in the UK HSE publication HSG65 *Successful Health and Safety Management*. To describe it simply, risk management is about:

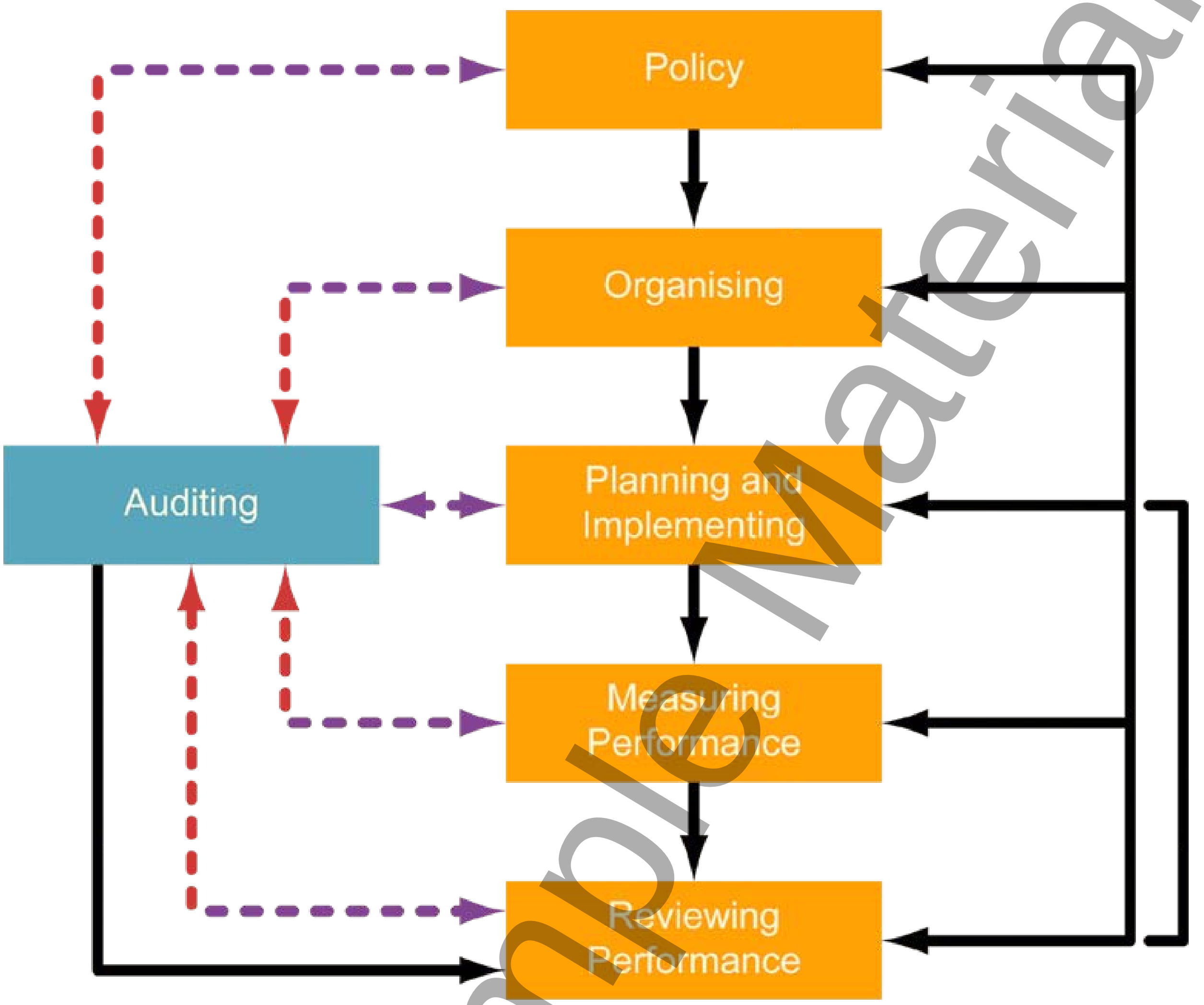
- Knowing exactly what your risks are and what you should be doing about them.
- Planning, prioritising and putting in place your risk controls.
- Making sure your risk controls are, and remain, effective.
- Reviewing and learning.

The UK HSG65 model is traditionally referred to as **POPMAR** – using the initials of the stages involved to describe the key elements of successful health and safety management:

P Policy

- **O** Organising
- **P** Planning
- **M** Measuring
- **A** Auditing
- **R** Review

The following figure illustrates this as a flow chart.



HSG65 "POPMAR" model risk management tool (Based on HSG65 Successful Health and Safety Management (2nd ed.), HSE, 1997 (http://www.hse.gov.uk/pubns/priced/hsg65.pdf))

The real "management of risk" falls mainly within the Planning and Implementing stage. Adequate precautions must be provided to control the process risks ("risk controls") and consideration should be given to the three stages within the risk control system, as shown.

INPUT	PROCESS	OUTPUT
Design/ construction	Routine & non-routine operations	Product & service design
Design/ installation	Maintenance	Packaging/ labelling
Purchasing/ procurement	Plant and process change	Storage/ transport
Recruitment/ selection	Foreseeable emergencies	Off site risks
Selection of contractors	Decommission	Disposal & pollution control
Acquisition	Demolition	Divestments
Information		Information

(Based on HSG65 Successful Health and Safety Management (2nd ed.), HSE, 1997 (http://www.hse.gov.uk/pubns/priced/hsg65.pdf))

Hazards and risks entering the organisation should be minimised at the **input stage**, and risks contained and controlled in the **process stage**. Risks should be prevented from going off-site or in the products and services at the **output stage**.

Critical to the oil and gas process industries is the containment of hazardous materials and the effects of hazardous processes and systems, as well as effective maintenance (especially in harsh operating environments) and process change procedures to ensure continuing plant integrity.

Applied in the project stage from concept, design and start-up, risk assessment and the development and implementation of risk controls will remain part of effective process safety management. You can see this in the input stage of our chart. Risk control systems will be needed for:

- **Physical resources**, such as:
  - Design, selection, purchase and construction of the oil or gas process workplace, i.e. the fields or rigs for exploration and production.
  - Design, selection, purchase and installation of oil and gas process plant; drilling and pumping equipment, etc.
  - Design, selection and installation of safety critical plant (deluge systems, etc).
  - Design and construction of workplace facilities, such as engineering and worker accommodation, welfare and recreation.
  - Plant and substances used by others (e.g. contractors).
- **Human resources**, such as:
  - Recruitment and selection of oil and gas process and production employees.
  - Selection of suitable contractors and support staff.
- **Information**, including:
  - Health and safety standards to be followed in oil and gas.
  - Health and safety guidance for oil and gas.
  - Health and safety law and changes (revisions, etc.).
  - Oil and gas process technical information relating to risk control.
  - Management information.
  - Development of a positive health and safety culture.

Of course, the risk control systems must be appropriate for, and proportionate to, the risks they are brought in to address. Where the risk assessment shows and introduces adequate risk controls at the **input stage**, attention must then move on to the **process stage** and controls needed to ensure continuing safe operation.

The hazards here are not necessarily hazards of design, but hazards created by the workforce, their equipment, and how it is used, and hazards associated with oil and gas processing. Risk control systems will need to deal with the four main areas of risk:

- **Production workplace** – the field or rig and its associated facilities and support systems; safe access and egress; work environment; welfare facilities and accommodation; pipelines and structures, and electrical and communications installations.
- **Plant and substances** – the drilling and pumping and transportation systems of the oil and gas, how the oil and gas are stored and handled, and all materials in use at the process area.
- **Procedures** – organisational procedures such as work and shift patterns, job design and the way work is done (and managed).
- **People** – management and leadership, competence and placement of workers, training and health surveillance necessary.

It is important not only to focus on the risks inherent to the processes, but also those "irregular" occurrences, such as breakdowns and emergencies. Events giving rise to foreseeable serious or imminent danger need particularly robust risk controls to be incorporated.

Concept of "As Low as Reasonably Practicable" (ALARP)

We have seen that it is a requirement to comply with all relevant health and safety law within oil and gas processing, and that both qualitative and quantitative risk assessment methods can be used. In all cases, there is a danger that the risk reduction methods may be decided upon for the wrong reasons – based on affordability rather than compliance with the law; and always the danger to stop when the legal requirement has been seen to be met. This is where "as low as reasonably practicable" comes in.

ALARP covers risk at levels of some uncertainty:

- **Unacceptable risk** – risk cannot be justified at this level except in extraordinary circumstances (intolerable).
- **ALARP** (tolerability region) – at the higher risk end, risk may be undertaken only if a benefit is desired, and where risk reduction is impracticable, i.e. grossly disproportionate to the benefits gained. At the lower risk end, risk is tolerable if the cost to reduce it would outweigh the benefits.
- **Acceptable risk** – where it is necessary to demonstrate risk remains this low, there is no need for detailed working to demonstrate ALARP. At the lower end, this is negligible risk (tolerable).

All risks should be reduced to ALARP, and in some cases cost-benefit analysis may be needed to determine the appropriate level of controls. All levels of risk should be compared with oil and gas industry guidance and best practice.

Other Risk Management Tools

Different approaches may be taken depending on the nature of the operations (offshore exploration or onshore refining and storage) and the sectors or areas they actually operate in. Methods include HAZOP, HAZID, FMEA, etc.; qualitative and quantitative risk analysis; security or terrorist management, or more specific and local hazard and risk analysis in pipelines; dispersion modelling for fire, blast and explosions; and blast resistance design and construction. Evacuation planning is also important, as is the correct siting of facilities used to assess the location of buildings/ modules based upon known hazards.

We will look briefly at some of these techniques.

- **HAZOP (Hazard and Operability Studies)** – first used by ICI in the 1960s to identify hazards in the design of their chemical plants. This technique identifies potential hazards so that suitable precautions can be introduced to control them, and is particularly useful in the design of chemical or other hazardous installations and processes. It is carried out by a multi-disciplinary team with expertise in design of the installation, commissioning, production and process operations, maintenance of the facilities and ongoing requirements for health and safety.

  HAZOP uses guide words to identify individual elements of the project, and the team uses "brainstorming" methods to determine how each guide word will apply in each element. The purpose is to identify any deviations from intended performance, what might cause such deviations, and their potential consequences.

  Where HAZOP identifies a significant risk, it will go on to specify what actions should be taken to reduce the risk to an acceptable level. This may involve changing the design, altering installation criteria, different maintenance and inspection requirements, or the introduction of particular safe operating procedures. The following table gives an idea of how the guidewords are used.

Guideword	Possible deviations
None	No flow of oil. No flow of gas. No electric current. No supply pressure. Reverse flow. Operational sequence missed.
More of (or Less of)	Quantitative increase in oil flow. Quantitative increase in gas flow. Relate to any quantitative increase or decrease in such parameters, e.g. flow, pressure, electric current, viscosity, volume, weight, temperature, dimension, etc.
Part of	Only part of the intention of the original design is achieved, e.g. a pipeline supply pressure, volume of captured oil from well, etc.
More than	There is something in the process not accounted for, e.g. level of contaminants or impurities (i.e. LSA scale), gas is present in a fluid (or *vice versa*).
Other criteria	• What other things can occur? • Instrumentation fault/failure. • Corrosion of components. • Failure of pressure vessel or pipework. • Sampling and monitoring activities. • Venting and system relief activation. • Service failure (cooling, lubrication, air). • Maintenance activities. • Hydrocarbon releases. • Flammable atmospheres. • Static electricity.

HAZID (Hazard Identification) – uses "brainstorming" techniques driven by the use of key words appropriate to the study being undertaken. HAZID is useful when considering changes to existing plant layout, the assessor often mapping hazards and their locations on a walk-through of the facility. Where this practical method cannot be used, then computer programmes can be utilised instead. As the name suggests, it is a hazard identification exercise that is intended to pick out as many hazards as possible for later risk assessment.

FMEA (Failure Modes and Effects Analysis) – a technique often used to calculate the possibility of failure or malfunction, usually of components in an assembly or piece of equipment, and to calculate the possibility of failure or malfunction of the assembly or equipment itself. This is an example of an inductive analysis, sometimes referred to as a "bottom-up" approach.

It lists individual components and items and looks both at their individual failure and their individual failure effects on the whole system. It questions performance by asking: "If this item fails, what will the result be?" Again used in the design stages of a new process it attempts to find potential problems before they actually happen.

It asks the basic questions:

– In what way can each component fail?
– What might cause this type of failure?
– What could be the effects of this type of failure?
– How serious could the failure be?
– How is each failure detected?

It uses technical drawings of the assembly and its components, and describes clearly the complete function of all the components and their bearing on the overall function of the assembly.

Industry Related Process Safety Standards

Inherently safe and **risk based** design concepts, and **engineering codes** and **good practice** are the foundations for onshore and offshore operational safety.

Inherently safer design concepts are particularly useful for risk reduction and are highly recognised and recommended by safety professionals as a first choice in process design practices.

Jargon Buster

Inherently safer designs

Designs where the design engineers use a variety of techniques to achieve risk reduction through design ("design it out" principle).

Such methods include:

- **Hazard elimination** – as it suggests, get rid of the hazards as a first priority, instead of accepting and reducing them with risk reduction strategies after assessment.

- **Consequence reduction** – if the hazards can't be eliminated, find less hazardous solutions to accomplish the same design objective using techniques such as reducing exposure to a hazard, or reducing the amount of hazardous materials kept in stock. We could also substitute hazardous with less hazardous materials.
- **Likelihood reduction** – here we attempt to reduce the likelihood (the probability) of a hazardous event from happening by techniques using simplification and clarity (lowering the likelihood of an initiating event) and layers of redundancy of safeguards (to reduce event progression).

While prevention, detection and mitigation are all considered for inherent safety, the emphasis should be on prevention. For example, moving the proposed location of a flammable liquid storage tank away from accommodation areas or, onshore, away from a public boundary around an installation, may greatly reduce the consequences of a release and could also reduce or even eliminate the costs of providing added protection systems that may be needed if not safely sited elsewhere.

Inherent safety includes the consideration of more than just design features of a process. The principles include human safety factors, in particular the opportunities for human error given the design and operating conditions and parameters.

Examples of inherent safety in action:

Error-Likely Situation	Proposed Solution
Controls too difficult to access.	Work to reduce clutter to give more working space.
Displays too complicated to understand easily; difficult to interpret information displayed.	Improve design and layout to reduce the chance of human error.

Summary of Inherently Safer Design Concepts

Hazard Elimination

Concept – eliminate hazards as first priority, rather than accept and deal with risks.

Methods:

- Eliminate use of a hazardous material.
- Substitute with a less hazardous material.
- Discontinue the operation.

Consequence Reduction

Concept – where elimination is not practicable, find less hazardous solutions to accomplish the same design objectives by focusing on the consequences of an adverse event.

Methods:

- Reduce quantities of hazardous materials.
- Provide a curbed area with a drain to contain and evacuate a spill, and produce a smaller pool area of a spill.
- Separate the operation (from critical areas) by adequate spacing to reduce exposure to adjacent operations and personnel.

Likelihood Reduction

Concept – where hazards can't be completely eliminated and after consideration of consequence reduction, consider ways to reduce the likelihood of events occurring.

Methods:

- Reduce the potential for human error through simplicity of design.
- Control ignition sources.
- Provide redundancy and alarms.

Sources of Written, Recognised Good Practice

- (UK) HSE Guidance and Approved Codes of Practice (ACoPS).
- National or local government guidance.
- Standards from international or national accredited providers (BS, CEN, CENELEC, ISO, IEC, etc.).
- Industry specific or sector guidance from trade federations, professional institutions.

Other sources of good practice, often unwritten, may be acceptable to national or local competent authorities providing they satisfy necessary conditions, such as the well-defined and established standard practices adopted in a specific industry or sector.

Good practice may change over time as technology improves the degree of control over a process or operation (which may provide an opportunity to use elimination and advanced engineering controls), cost changes (perhaps allowing control at lower costs) or because changes occur in management practices.

Good practice may also change because of increased knowledge about the hazard and/or a change in the acceptability of the level of risk control achieved by the existing good practice.

In the definition of good practice, "law" refers to that law acceptable to the situation in question (determined by national or local competent authorities); such law may set absolute standards (e.g. 'shall') or its requirements may be qualified in some other, less stringent way (e.g. 'practicable' or 'reasonably practicable').

'Good practice', as understood and used by the UK HSE, can be distinguished from the term 'best practice' which usually means a standard of risk control above the legal minimum.

Concept of Hazard Realisation

This concept is not only about asking "*What if?*" but also taking a more detailed look to attempt to know the "*What if?*" before it actually happens. We can use as an example the loss of containment of hydrocarbons that would lead to ignition; which leads to fire or explosion; which leads to damage and injury to workers.

Key Risk Assessment Issues Relating to Loss of Containment Causing Hydrocarbon Releases (HCRs)

- Major source of HCRs: system piping (piping, flanges, valves) and instrumentation (i.e. Small Bore Tubing systems (SBT)).
- Main operating systems experiencing HCRs: gas compression.
- Biggest operational cause: wrongly fitted equipment.
- Next biggest operational cause: incorrect or improper operation (human factors).
- Main procedural cause: failure to comply with procedures (human factors).

The UK HSE figures reveal that in an eight year period from 2000/2001, instruments (SBT) were the largest single contributor to HCRs greater than 25kg. They further show that inspections and surveys on SBT systems suggest that 26% of fittings examined contained faults, e.g. under-tightness, incorrect or mismatched components, leaks, incorrect or poor installation, etc. and that this failure has been consistent since 2001.

(Source: Offshore Information Sheet No.2/2009, Hydrocarbon Releases (HCRs) Offshore, HSE, 2009 (http://www.hse.gov.uk/offshore/infosheets/is2-2009.pdf))

What we have detailed above are the causes of hydrocarbon releases, which must be addressed by risk controls. Our "*What if?*" scenario needs to show, based on the size and location of the hydrocarbon release, what the potential results, in damage and injury/loss of life, could be. This potential will enable us to determine priorities around which we introduce the risk controls to prevent the hydrocarbon releases.

We start with the **worst case scenario**:

What?

- A major HCR (e.g. above 25kg).

Where?

- From piping or instrumentation.
- On a gas compression unit.
- In close proximity to a welfare or accommodation facility.
- With uncontrolled ignition sources in the vicinity (e.g. electrical fault).

When?

- At a time when occupation of that facility is greatest (e.g. in a canteen at a main mealtime), e.g. 34 workers (50% of staff).
- The deluge system is on manual override due to maintenance work.

How?

- Poorly maintained piping or instrumentation with incorrect fittings and not correctly tightened.

Why?

- No planned preventive maintenance or inspection programme.
- No detection equipment for hydrocarbon releases.
- No emergency action plan in place for hydrocarbon releases.
- No fire-fighting equipment in the vicinity of the release. (or fire fighting equipment empty/not maintained/moved).
- Poor fire-fighting training for personnel.
- Poor response by personnel/lack of response training.
- Lack of management leadership decisions.

Hopefully this is an exaggerated circumstance, and many of the variables will already have been dealt with by the design of the installation (i.e. no welfare or accommodation near gas compressors) but the analysis can be used to give us the opportunity to examine the realisation of this type of hydrocarbon release hazard. How likely is it (what is the probability) that of all of these events (and we could possibly discover more by a greater in-depth analysis) will actually happen at the same time? Were they to happen, what would be the severity (the consequences) of the release?

Again, we start with the **worst case scenario**:

What?

- Hydrocarbon release is ignited by electrical fault.
- Explosion and fire engulf the canteen.
- All 34 workers in the canteen are lost.
- Gas compression unit destroyed by blast.
- Gas process operation lost – long downtime.

Why?

- No warning of hydrocarbon release.

- No water from the deluge system.
- Long release duration.
- Fire-fighting media not available.
- All on-shift workers in other areas.
- No trained response team.
- No emergency action plan or EER (Escape, Evacuation and Rescue).
- Time taken to get response teams to location too long, etc.

You need to continue this process to discover all the consequences, however minor.

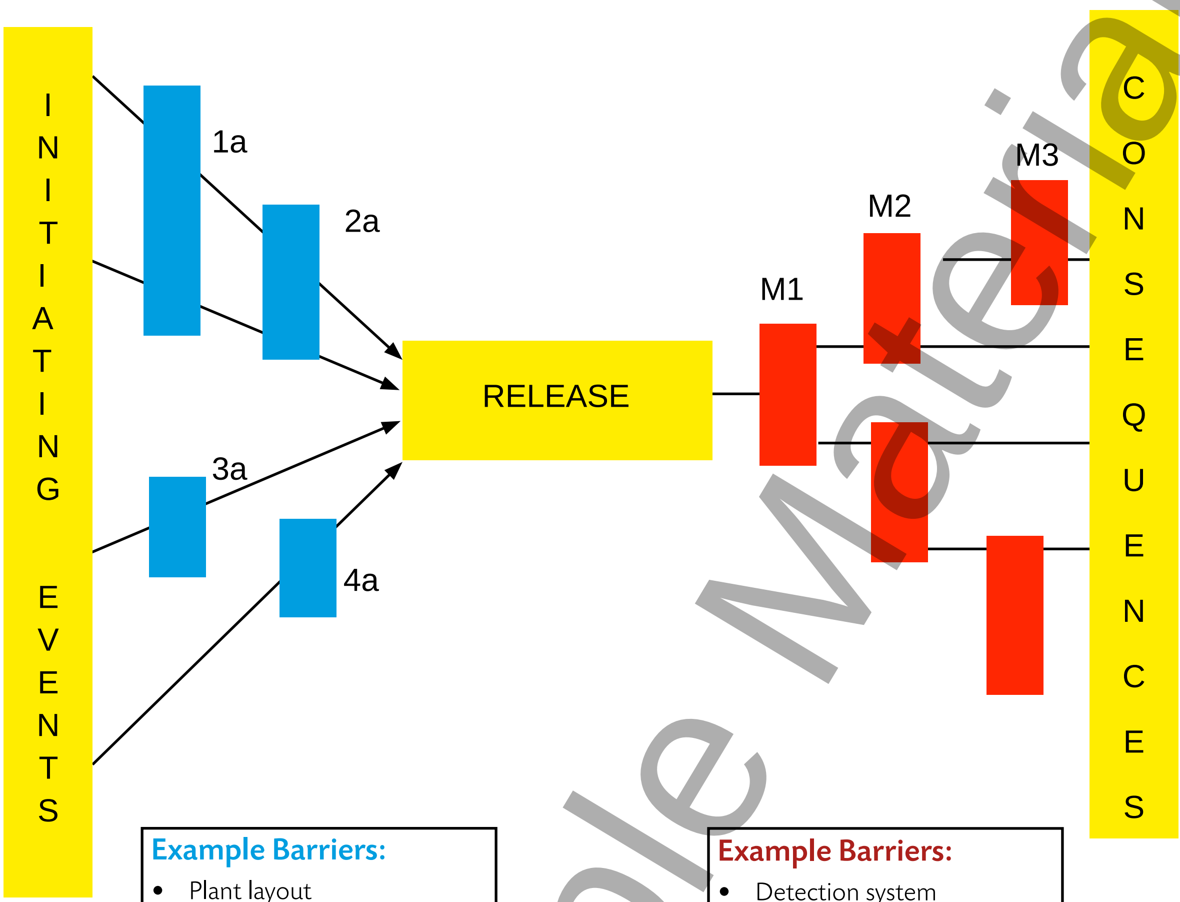
As you work down the possibilities within each scenario, you begin to eliminate or reduce some of the consequences **and** the probability of them occurring. For instance, if there are **no** welfare or accommodation facilities in proximity to the gas compressors, then this leg of the trail will not be there, and we will not lose 50% of our crew. If the fire deluge system is **not** on manual override, water **will** be available to deal with a fire, etc.

Concept of Risk Control Barrier Models

As well as the risk controls we have looked at, we could also consider placing barriers between the event and its results, or placing a barrier between the hazard and its realisation.

An example given by the UK HSE in the Offshore Information Sheet No 3/2006 illustrates the concept of using barriers in a **bow-tie diagram** which represents all of the initiators of the scenario and the consequences. Between the initiators and the consequences, barriers are placed that should prevent, control or mitigate the outcome of the event. In this case such barriers are known as Lines of Defence (LOD) or Layers of Protection (LOP).

Reference numbers can be assigned to barriers which are common to several event initiators for a particular scenario (see barrier 1a in the following diagram, which comes between two initiators and the release) as well as those common to several scenarios.



Example Barriers:

- Plant layout
- Construction standards
- Inspection
- Instrumentation

Example Barriers:

- Detection system
- ESD (Emergency Shut Down)
- Active protection
- Passive protection
- EER (Escape, Evacuation & Rescue)

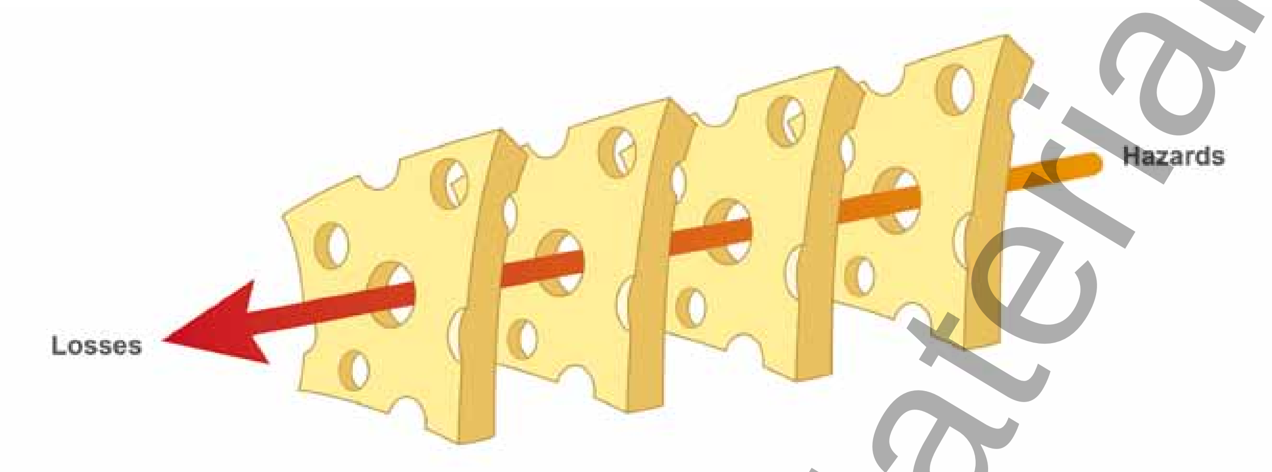
Based on Offshore Information Sheet No.3/2006, Guidance on Risk Assessment for Offshore Installations, HSE, 2006 (http://www.hse.gov.uk/offshore/sheet32006.pdf)

Use of Modelling

Thermal Radiation Output, Blast Zones for Risk Assessment

A major objective behind optimised plant layout is the avoidance of incidents leading to fire or explosion and the protection of people, assets and reputation. This requires good separation between hazardous and vulnerable areas. Separation can be determined by the use of modelling systems, which will also show the value of minimisation of equipment, liquid hydrocarbon inventory in process equipment, vulnerability through selection of the type of equipment and exposure of people through process related complexity and maintenance.

As well as the bow-tie system, models use barriers such as that shown below, the Swiss-cheese model. In this system, barriers are used between hazards and consequences (hazard losses or hazard realisation). Such barriers could be design features, shutdown and alarm systems, operations and procedures, etc.



Swiss Cheese Barrier Model

Modelling

There now exists a body of data and sophisticated modelling software that can, for example, estimate:

- Evaporation rate of flammable liquids (e.g. from a spill).
- Dispersion of leaking vapours/gases, including the likely concentrations at given points on and off-site, taking account of vapour density and any propensity to settle in low-lying areas.
- Likely types, effects and scale of any fires and explosions – the rate of pressure rise, maximum pressure, intensity of thermal radiation (for different fire types) and other parameters can be estimated.

Modelling is a valuable predictive tool used to explore the significance of possible major hazard scenarios and so help decision making. Apart from the information already identified above, it also enables:

- Identification of the key contributors to explosion risks – this helps prioritisation.
- Exploration of the effectiveness of existing preventive and protective measures – which could help justify the adequacy of your existing controls.

Modelling is also obviously useful in safety case justifications.

There are many modelling systems available and some are substance specific, e.g. LNG.

Revision Questions

12. The UK HSG65 safety management systems employ POPMAR – what does this stand for?
13. What are the four main areas of risk to be dealt with in oil and gas processing risk control systems?
14. In risk control barrier models (e.g. bow-tie) between what criteria are barriers placed, and what are the barriers called?

(Suggested Answers are at the end of Unit IOG1.)

An Organisation's Documented Evidence

Key Information

- Organisations must have documented evidence that their safety systems are adequate, including safety cases and safety reports, which can be used to meet both legal requirements and best practice.

Organisations are required to produce evidence that gives a convincing and valid argument that a system is adequately safe.

Examples of Documented Evidence

Safety Cases

In some countries, all production operators must have a safety case in place which clearly identifies all installations covered by it, and in the specific case of a **production installation**, which shows:

- Details of the operator (name and address).
- A design notification that includes:
  - A description of the design process from initial concept to the submitted design (and the design philosophy used to guide the process).
  - A description of the design concept with diagrams and summary of other design options considered.
  - How the design concept will ensure legal compliance.
  - How the design concept will ensure that risks having the potential to cause a major accident are reduced (to ALARP).
  - The criteria used to select the chosen design concept and how the selection was made.
- The design notification is to include a description of:
  - The principal systems on the installation.
  - The installation layout.
  - The process technology to be used.
  - The principal features of any pipeline.
  - Any petroleum-bearing reservoir intended to be exploited using the installation.
  - The basis of design for any wells to be connected to the installation.
- A summary of how any safety representatives for that installation were consulted with regard to the revision, review or preparation of the safety case, how their views were taken into account, etc.

The safety case details continue with:

- A description, with suitable diagrams, of the main and secondary structure of the installation and its materials.
- A description of its plant (machinery, equipment or appliance such as drilling, well maintenance and production testing plant).
- A suitable plan of the location of the installation and of anything connected to it.
- Particulars of the meteorological and oceanographic conditions to which the installation may foreseeably be subjected.
- The properties of the sea-bed and subsoil at its location.
- Particulars of the particular types of operation and activities in connection with the operation which the installation is capable of performing.
- The maximum number of persons expected to be on the installation at one time and for whom accommodation is to be provided.
- Particulars of the plant and arrangements for the control of well operations, including those to:
  - Control pressure in a well.
  - Prevent the uncontrolled release of hazardous substances.
  - Minimise the effects of damage to sub-sea equipment by drilling equipment.
- A description of any pipeline with the potential to cause a major accident, including:
  - The fluid which it conveys.
  - Its dimensions and layout.
  - Its contained volume at declared maximum allowable operating pressure.
  - Any apparatus and works intended to secure safety.

- A description of how the duty holder has ensured (or will ensure) that people on the installation are protected from fires and explosion and for ensuring effective emergency response.
- A description of the arrangements made for protecting persons on the installation from toxic gas at all times other than during any period while they may need to remain on the installation following an incident which is beyond immediate control.
- A description of the measures or arrangements for the protection of persons on the installation from explosion, fire, heat, smoke, toxic gas or fumes during any period they may need to remain on the installation following an incident which is beyond immediate control and for enabling such persons to be evacuated from the installation where necessary, including:
  - Temporary refuge.
  - Routes from locations where persons may be present to temporary refuge and for egress therefrom to points from where the installation may be evacuated.
  - Means of evacuation at those points.
  - Facilities within the temporary refuge for the monitoring and control of the incident and for organising evacuation.
- A description of the main requirements in the specification of the design of the installation and its plant which shall include:
  - Any limits for safe operation or use specified therein.
  - A description of how the duty holder has or will comply with **any specific requirements of the national competent authority**.
  - A description of how the duty holder in relation to a pipeline has or will ensure their operation within safe limits, or
  - Where he is not also the operator in relation to a pipeline, has or will cooperate with the operator to ensure their operation within safe limits.
- Particulars of any combined operations which may involve the installation, including:
  - A summary of the arrangements in place for co-ordinating the management systems of all duty holders involved in such a combined operation.
  - A summary of the arrangements in place for joint review of the safety aspects of any such combined operation by all duty holders involved, which shall include the identification of hazards with the potential to cause a major accident and the assessment of risks which may arise during any such combined operation.
  - The plant likely to be used during such combined operations.
  - The likely impact any such combined operation may have on the installations involved.

Safety Reports

Safety reports make "demonstrations" and the information they contain should relate to:

- The management system and the organisation of the establishment with a view to major accident prevention.
- Description of the environment of the establishment.
- Description of the installation.
- Hazard identification, consequence assessment, risk analysis and prevention methods.
- Measures of prevention and intervention to limit the consequences of a major accident.

Where Such Documented Evidence is Used

Safety Cases

Safety cases are legally required in some countries, and in the UK the **Offshore Installations (Safety Case) Regulations 2005 (OSCR)** require operators of all installations to prepare a safety case where their operations will be located in British waters and in UK designated areas of the continental shelf. It will be an offence to operate in these areas without a safety case that has been submitted to the UK Health and Safety Executive (HSE). Different requirements will apply to installations used or producing oil and gas and to those used for other purposes such as drilling, exploration or for providing accommodation.

A single duty holder has the duty to submit the safety case for each type of installation, usually the **operator** of a production installation and the **owner** of a non-production installation.

- **Notification**

  Operators of all new offshore production installations must notify the HSE (or in other countries, their competent authority) at the early design stage (see above). Notification is also necessary if a production installation is to be moved to a new location or if a non-production installation (such as a drilling rig) is to be converted for production purposes.

  Further notification is required if installations engage in combined operations, to cover all aspects of those combined operations. Particular attention **here is** on co-operation and co-ordination between the installations.

  A **safety case** must follow the notification, and production cannot begin until the HSE or other national competent authority accepts the safety case. Where an installation that is to be moved already has a safety case, a revision of it must be submitted for acceptance. A revised safety case must also be submitted and accepted before a fixed installation can be dismantled. If a non-production installation is to be moved into UK waters to be operated there, its owner must submit a safety case and have it accepted before it can be moved there.

- **Acceptance**

  The HSE or national competent authority will "accept" a safety case (or a revision of one) when duty holders demonstrate and describe specified matters to the HSE's satisfaction, i.e. in their judgment, all measures described in the safety case are **likely** to achieve compliance – they do not have to be satisfied that it **will** be achieved. This will be confirmed in post-acceptance programmes of inspection and enforcement. It must always be understood that acceptance of a safety case does not guarantee the safety of the installation or its operators.

Safety Reports

Safety reports may be required in various countries, and are needed in the UK to ensure safety of sites under the **Control of Major Accident Hazards Regulations 1999**. Writing the safety report demonstrates how you meet the duties set out for operators in these Regulations.

Safety reports must demonstrate that safety measures **are** in place to prevent the occurrence of major accidents associated with (specified) amounts of hazardous substances on the site, and to limit their consequences should they occur. There is also emphasis on measures in place to protect the environment.

The safety report should be submitted to the local office of the HSE or national competent authority who, together with other national agencies such as environmental enforcing agencies, will work together to assess the report.

Purpose of Documented Evidence

Safety cases are required to ensure that those having duties under the national regulations (e.g. OSCR), i.e. licensees, installation operators, installation owners, well operators and others involved in offshore activities, design, construct, commission and operate their facilities in order to reduce the risks to the health and safety of those working on the offshore installations or in connected activities to as low as reasonably practicable (ALARP).

The safety case is a document that demonstrates (to the duty holder and the national competent authority) that the duty holder is capable of controlling major accident risks effectively. It is a core document for checking by both parties that risk controls and safety management systems are in place and operate as they should.

Like the safety case, a **safety report** contributes to preventing major accidents on sites having specified amounts of hazardous substances, normally onshore.

It demonstrates that you have measures in place to prevent major accidents and limit consequences to people and the environment. It systematically examines the site activities, and the potential for major accidents and what is or is going to be done to prevent them. Importantly, it shows that you have used a systematic process to arrive at the risk controls, showing the depth to which you have gone to develop them. It shows you can correct any shortcomings.

Typical Content of Safety Cases and Safety Reports

We have seen the list of both technical detail and procedural information that is required to put together the safety case for submission to the national competent authority. Content in some of these areas can include:

- Identification of **major accident hazards** using risk assessments (Q, SQ, QRA), bow-tie diagrams, etc. and criteria from previous operations and incident records, as well as design drawings and calculations. The impacts of potential major accident hazards should be analysed and summarised, and should identify:
  - Each hazard scenario.
  - Threats to safety and what causes them.
  - Barriers to prevent those threats.
  - Consequences of each threat were it realised.
  - Recovery measures required.
  - Factors that could escalate the hazard or its consequences.
- Evaluation of **major accident risks** and measures taken (or to be taken) to control those risks, using details of all existing "designed-in" precautionary and safety measures. Existing and previous risk controls should be included, then evaluated to see if these are adequate or if further risk controls are required to demonstrate ALARP. This would include:
  - Identify each hazard/incident scenario.
  - Assess frequency criteria.
  - Assess consequence criteria.
  - Assess occupied and unoccupied locations as separate criteria.
  - Assess Evacuation, Escape and Rescue (EER) facilities and requirements.
  - For higher risks, assess individually.
  - Identify and assess the risk control measures proposed to achieve ALARP.

- Arrangements for **audit and audit reports** with a plan showing the type of audit (internal, external), how often they will be carried out, in what areas they will be conducted, how recommendations will be dealt with and actioned, and who will be responsible for completion.
- Having an adequate **safety management system** in place, including the management of contractors and sub-contractors. Selection criteria and approved lists of contractors would be held, together with all returned data from contractors (such as safety questionnaires confirming competence, insurances, etc.).
- **Major accident prevention policies** - in the case of safety reports these would need supporting information from the safety management system.
- Identification of the **safety critical elements** that are in place to manage major accident hazards (scenarios, possible causes, controls, recovery systems).
- Details of the **emergency plan**. This would include layout drawings of the installation, showing locations of all safety and emergency equipment, control points (e.g. control room, radio room, etc.), isolation and shut-off controls, safe access routes and escape ladders, access to boats and manning and launch procedures.

Revision Questions

15. What main areas does a safety case/safety report cover?

(Suggested Answers are at the end of Unit IOG1.)

Summary

This element has dealt with health, safety and environmental management issues facing those in control of oil and gas process operations. In particular it has:

- Explained the purpose of investigating accidents and the procedures available, including a discussion of the lessons that can be learned from previous incidents that can be used to improve health and safety in the oil and gas industries.
- Explained the hazards that are inherent in oil and gas processing from the extraction, storage and processing of raw materials and products, and given definitions of specific terminology used. The properties and hazards of gases and other substances, as well as materials and additives used in or created by the processing of oil and gas, were discussed.
- Outlined the risk management and risk assessment techniques available.
- Explained the purpose and content of an organisation's documented evidence to provide a convincing and valid argument that a system is adequately safe in the oil and gas industries. This included details of the use of safety cases and safety reports.

Exam Skills

30

Introduction

To pass the NEBOSH Certificate you need to perform well during the exams. You only have two hours and your performance will be related to two key factors:

- The amount that you can remember about the elements you've studied; and
- Your success in applying that knowledge in an exam situation.

Being good at both aspects is essential. Being calm under exam pressure is pointless if you do not have a good knowledge of the information required to answer the exam questions.

Here we will consider some practical guidelines that can be used to increase success in the exam. Then you will find Exam Skills questions to answer at the end of each element, starting with this one.

Exam Requirements

The IOG1 exam consists of two sections:

- Section 1 contains one question which is likely to consist of a number of sub parts. This question in total is worth 20 marks.
- Section 2 contains ten questions with each question being worth eight marks.

There is no choice of questions in the exam - all questions are compulsory. The exam in total lasts two hours and NEBOSH recommend that you spend about:

- Half an hour on Section 1; and
- One and a half hours on Section 2.

Exam Technique

In the exam, candidates can often struggle because they have not understood the question that is being asked. They can interpret questions wrongly and as such provide an answer for the question they think is in front of them but in reality is not. To try to overcome this issue, let's look at a step-by-step approach that you can adopt when answering exam questions:

1. The first step is to read the question carefully. Be sure you know exactly what type of information the question wants you to give in your answer.
2. Monitor the time. The 20-mark question in the first section should take around 25 minutes to answer, with five minutes' reviewing time. The eight-mark questions in Section 2 should take around eight minutes to answer. This will leave an accumulated time of ten minutes at the end of Section 2 to review your answers.
3. Next, consider the marks available. For each mark to be awarded the examiner will expect a piece of information to award the mark against.
4. The next stage is to develop a plan – there are various ways to do this. Remind yourself again of the content of the question. Focus on key words that you have underlined on the examination paper to make sure you answer the question set. The answer plan is your aide-mémoire and can take the form of a list or a mind map that helps you unload information quickly and makes sure you have enough factors (or points) in your answer that will attract the available marks. Keep re- reading the question to ensure your answer plan is going to answer the question set.
5. When composing your answer it is essential that you pay proper attention to the action word (e.g. outline, describe, identify, explain) that has been used in the question. Candidates lose marks if they take the wrong approach. Remember you made a list to help your memory. NEBOSH will not be asking for a list anywhere on the paper, so if you reproduce your answer plan in the answer, you will not gain the available marks. The action word informs you about the amount of information the examiner is expecting you to provide on the factors you have listed.

Exam Skills

30

Below are a few of the most commonly used action words with a translation of their meaning:

- **State** – say what it is – there is often no widely recognised definition. This should not require a huge amount of detail - a less demanding form of the verb 'define'.
- **Identify** – select and name - commonly used in the Certificate exam.
- **Outline** – give the key features of. You need to give a brief description of something or a brief explanation of reasons why. This is less depth than 'Explain' or 'Describe' but more depth than a list. A great amount of depth and detail is not required. Outline is commonly used in the Certificate exam.
- **Describe** – provide an in-depth description, a word picture of what the thing is, what it looks like, how it works, etc. For 'Describe' questions a great amount of detail is needed. This is sometimes used in the Certificate exam.
- **Explain** – provide a detailed explanation - reasons why, reasons for, how it works, etc. Again, a great amount of detail is required. 'Explain' is usually used in a subdivided question so the detail required is tested in a narrowed-down field.

When it comes to the exam, make sure you indicate clearly your Answer Plan and your Final Answer for the examiner.

Exam Skills Practice

At the end of each element there is an Exam Skills question (or two) for you to attempt, with guidance on how to answer in addition to a suggested answer outline. This includes an Answer Plan – all of the points listed in this would attract marks and you will see most of them developed in the suggested answer itself.

Remember that when answering exam questions, information from additional reading and personal experience may be included. Examining bodies encourage this and it will enhance your answers.

There is a time estimate at the beginning of each Exam Skills activity. Don't worry if the activity takes you a little longer than this - the timings are just there as a rough guide.

Please feel free to contact your tutor if you have any queries or need any additional guidance. (You can do this by telephone or via the e-mail system in the e-Zone.)

Question

(a) Explain the meaning of the term "flash point". (2)

(b) Identify the three classifications within flammability. (3)

(c) With the use of a sketch, outline where the flammable range falls within flammable limits. (3)

Approaching the Question

- Using the system we have covered, the first thing to do is read the question carefully. You are asked this question in three parts - to provide an explanation of what 'flash point' means; identify the three classifications of flammability; and outline how flammability falls within flammable ranges. You should structure your approach in your Answer Plan.
- Next consider the marks available. In this question there are eight marks; we can see that the question is split into three different parts, with marks shown for each part. The question should take you around nine minutes to answer.
- Now highlight the key words. In this case this might look like this:

  (a) Explain the meaning of the term "flash point". (2)

  (b) Identify the three classifications within flammability. (3)

  (c) With the use of a sketch, outline where the flammable range falls within flammable limits. (3)
- Read the question again – make sure you understand it.
- Following this, the next stage is to develop a plan. Remember a plan can be completed in various ways, but it could consist of the following:

Suggested Answer

Plan

Flash point	Lowest temp. – vapour given off – can be ignited
Classification of flammability	Flammable Highly flammable Extremely flammable
Flammable range	Sketch – LFL UFL – flammable range show 'too lean', 'too rich' etc. and notations for fuel and oxygen on the bottom

Now have a go at the question. Take care and try to produce a good quality sketch – use a ruler for straight lines, and label it clearly (it **doesn't** have to be coloured like the example shown).

Remember you can contact your tutor if you have any queries.

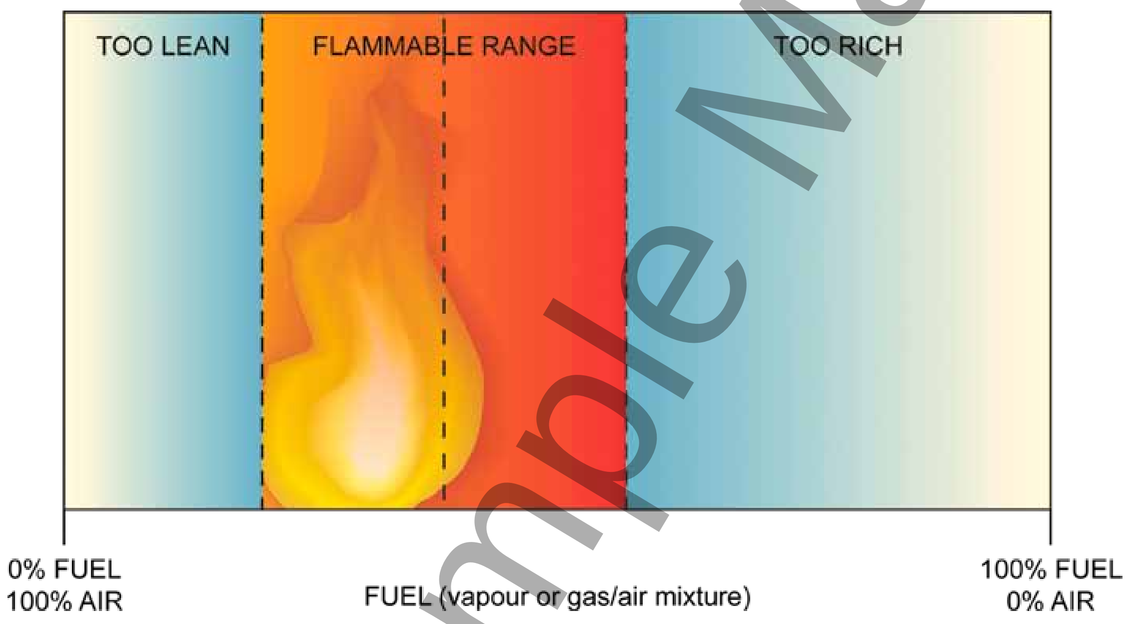
Possible Answer by Exam Candidate

(a) *"Flash point" is the lowest temperature at which sufficient vapour is given off to "flash" – that is, ignite momentarily (and not carry on burning) when a source of ignition is applied to the vapour.*

(b) *Flammability falls into three distinct classifications:*

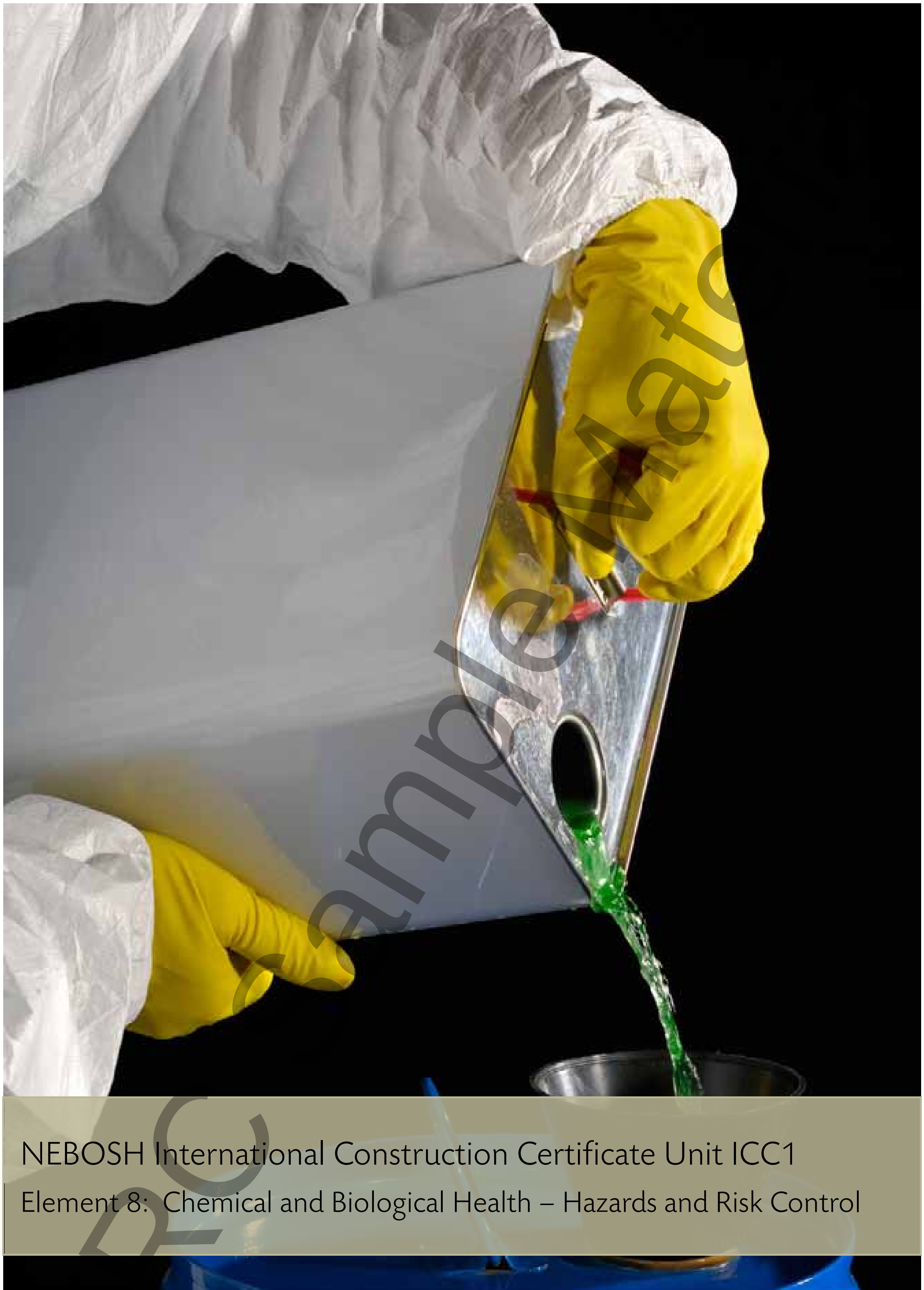
- *extremely flammable – flash point below 0° Celsius*
- *highly flammable – flash point between 0° and 21°*
- *flammable – flash point between 22° and 55°*

(c)



Reasons for Poor Marks Achieved by Candidates in Exam

- Not answering the question at all. If you do not attempt all questions required you cannot get any marks.
- Not following a structured approach: remember, the question has three distinct parts, and asked for explain, identify and outline, so a list would not gain marks.
- Sketch of poor quality, not correctly labelled, with inaccurate data.
- Giving lots of other information not relevant to the question.



NEBOSH International Construction Certificate Unit ICC1

Element 8: Chemical and Biological Health – Hazards and Risk Control

RRC TRAINING

Contents

Learning Outcomes

On completion of this element, you should be able to demonstrate understanding of the content through the application of knowledge to familiar and unfamiliar situations. In particular you should be able to:

- Outline the forms of, and classification of, and the health risks from exposure to, hazardous substances.
- Explain the factors to be considered when undertaking an assessment of the health risks from substances encountered in construction workplaces.
- Explain the use and limitations of Occupational Exposure Limits including the purpose of long-term and short-term exposure limits.
- Outline control measures that should be used to reduce the risk of ill-health from exposure to hazardous substances.
- Outline the hazards, risks and controls associated with specific agents.
- Outline the basic requirements related to the safe handling and storage of waste on construction sites.

Forms and Classification of, and the Health Risks from Hazardous Substances

Key Information

- In construction activities, many different forms of chemical hazards occur – dusts, fumes, gases, vapours and liquids. The form they are in can significantly affect how they might enter the body.
- Many hazardous substances do not come in containers labelled with information, but are created from the construction activities, such as cutting concrete.
- 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.

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 also lead to permanent lung damage from prolonged or repeated exposure.

We will take a look at the forms and classifications of chemical and biological agents that cause these short-term and long-term effects.

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 machine-made (formerly 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 as well as

good personal hygiene practices.

- **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.

Jargon Buster

Dermatitis

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 may be reportable under national or local regulations in certain cases.

Main Classification of Hazardous Substances

Chemicals can be broadly classified into three types; 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 common in Europe** 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 change to 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 substances 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 some 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 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 (chronic) over a number of years.

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 ICC1.)

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.

(Continued)

Topic Focus

  – **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 find their way into the body by this route.

- **Absorption** through the skin - the substance passes through the skin from direct contact with the agent or 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.

(Continued)

Topic Focus

- **Injection** through the skin - 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.

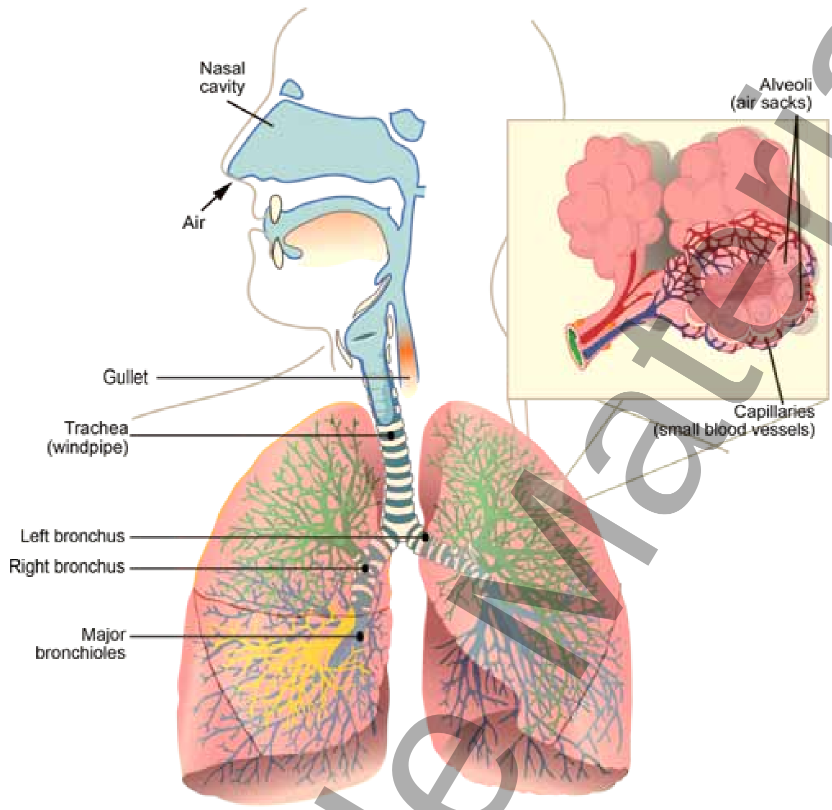
Although not a main route of entry, **aspiration** can also occur – where a substance already swallowed can be inhaled into the lungs – usually if a person is unconscious.

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 up by these cilia out of the lungs. Particles above 7 microns trapped in the mucus are cleaned from the lungs by this mechanism.



The Respiratory System

Cellular

- **Macrophages** – scavenging white blood cells attack and destroy particles (less than 7 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 International Labour Organisation's **1992 Code of Practice Safety and Health in Construction**. In Section 17.1 it requires "the replacement of hazardous substances, equipment or processes with substances, equipment or processes less harmful or hazardous to workers' safety and health".

(Copyright © International Labour Organisation 1992)

The risk assessment carried out to satisfy the national or local regulations controlling hazardous substances should follow a standard five steps approach:

- Gather information about the substance used, the people who might be exposed and the work activities carried out.
- Evaluate the health risks – are current controls adequate?
- Identify any further controls and implement them.
- Record the risk assessment and actions taken.
- 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?
- **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 last 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?
- **Number of people** potentially exposed and any vulnerable groups or individuals – such as expectant mothers or the infirm.
- **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 risk assessment, and then the adequacy of any existing control measures can be decided and additional controls and precautions selected.

Sources of Information

National regulations will apply with regards to the classification of chemicals and substances in terms of the hazards they present, e.g. in the USA the American Conference of Governmental Industrial Hygienists (ACGIH) determine threshold limit values for over 700 chemical substances and physical agents, as well as over 50 biological exposure indices. There are requirements for the provision of information to the users of chemicals, e.g. labelling of chemicals and by safety data sheets.

Jargon Buster

Safety data sheets

Provide all necessary information about the substance – for transport safety and to help in carrying out the risk assessment.

The **Classification, Labelling and Packaging Regulation (CLP)** (EC Regulation 1272/2008) and the European **Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation** provide a good foundation for general chemicals regulation.

As we saw earlier with the change to GHS labels, the European (CLP) Regulation is based on a Globally Harmonised System.

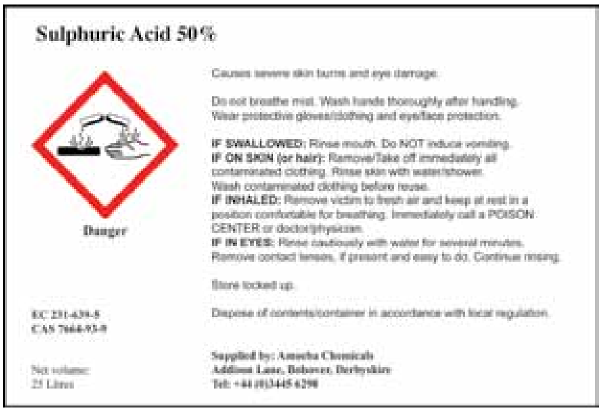
Product Labels

Substances that are classified (by international or national regulations) as dangerous for supply are to carry a product label, which must give the following information:

- The name of the substance/preparation.
- The name(s) of the hazardous constituents.
- The indication(s) of danger and the corresponding symbols.
- The risk phrases.
- The safety phrases.
- Within Europe – the words "EC label" (if the substance is on the Approved Supply List) and the EC Number – for substances only (i.e. not required for preparations).
- 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

EU List of Indicative Limit Values

The EU List of Indicative Limit Values (or indicative occupational exposure limit values (IOELVs)), shows the human exposure limit values to hazardous substances that are specified by the Council of the European Union. These were introduced in 1980, and are not binding on member states directly as published, but are to be taken into account when putting in place national or local control measures to prevent or reduce exposure to the substances.

HSE List of Workplace Exposure Limits (UK)

The UK HSE publish the document EH40 which shows the Workplace Exposure Limits (WELs) which meet the requirements of UK hazardous substances legislation. These exposure limits are binding on UK workplaces – they require employers to reduce exposure to hazardous substances to as low a level as possible, and certainly below the limits stated.

ACGIH List of Threshold Limit Values (USA)

In the USA the ACGIH publishes lists of threshold limit values (TLVs) (see earlier) that refer to exposure to hazardous substances, and BEIs (Biological Exposure Indices) which are particularly associated with biological hazards. These are published as guidelines – not standards – that are used by industrial hygienists when determining safe levels of exposure in the workplace.

Safety Data Sheets

National or local regulations will require information about hazardous substances to be provided on safety data sheets. In the EU, Article 31 of **REACH** requires suppliers of dangerous substances and preparations to provide safety data sheets.

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.

It is generally the responsibility of the supplier to provide the safety data sheets, either as hard (paper) copies or in electronic format free of charge the first time the hazardous substance is supplied to a user. They must be kept up to date by the supplier and revised and re-issued accordingly.

Topic Focus

Information typically to be included by the supplier on safety data sheets:

- Identification of the substance or preparation, and supplier - 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).

More...

You will find it useful to read *REACH – the Registration, Evaluation, Authorisation and Restriction of Chemicals Regulation* Technical Update which is available to download from the Free Resources area of the RRC website, at http://rrc.co.uk.

Limitations of Information in Assessing Risks to Health

These sources of information we have discussed 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 the individual worker 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?

Assessment of Exposure to Hazardous Substances

Assessment of exposure to hazardous substances usually involves monitoring surveys, which 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 50 parts-per-million (ppm).

Limitations of stain tube detectors:

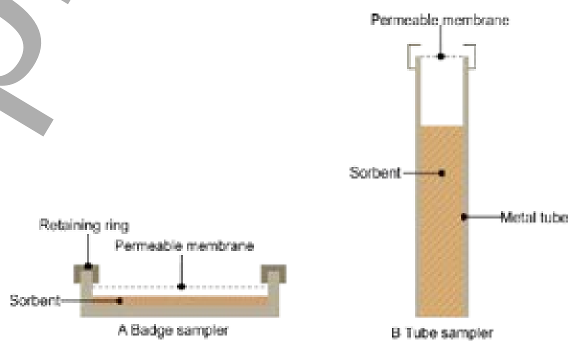
- Provide a spot sample for one moment in time rather than an average reading.
- Can have an accuracy of +/-25%, which is not particularly accurate.
- Correct number of strokes must be used; losing count and giving too few/too many will give inaccurate results.
- Volume of air sampled may not be accurate 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.
- The **tube-type sampler** has a smaller permeable membrane supported over a deep metal tube filled with sorbent.

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.



Passive (Diffusion) Samplkers

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, making them ineffective.
- Size of the sample is imperative. If the samplers are

only used intermittently or only a small sample is used, results may be misleading.

Oxygen Meters

Direct reading instruments are available to monitor and warn of concentrations of the toxic gases carbon dioxide, carbon monoxide or hydrogen sulphide in the atmosphere, as well as the essential gas, oxygen, in naturally occurring respirable air. They are reliable and accurate.

They indicate concentrations of oxygen in the atmosphere on a simple dial or digital readout. To do this an air sample diffuses into the sensor through a special membrane, where the resultant electrochemical process produces electric current directly proportional to the oxygen concentration.

These instruments can be pre-set to a given oxygen concentration which activates an audible or visual alarm system. They are used both as personal monitors and to measure room concentrations of oxygen (e.g. in a confined space).

The normal percentage of oxygen in air is 21%, most of the remainder (78%) being nitrogen.

Limitations of oxygen meters:

- Sensitive (but accurate) sensors, so are sometimes delicate and need careful handling.
- Need some skill to accurately set and monitor.
- Battery needs to be proven for capacity before use.

Smoke Tubes

These are simple devices that generate non-toxic smoke in a controlled chemical reaction. They are similar in appearance and operation to stain tubes - you break open the tube and attach a rubber bulb to emit the smoke.

Smoke tubes are used to assess the strength and direction of air flow. The smoke they release is carried away by the air currents in the local environment and the movements observed. Such smoke tests are ideal for checking the effectiveness of ventilation and extraction systems, air-conditioning systems and chimneys. They can be used to detect leaks in industrial equipment, to assess relative air pressures used in certain types of local ventilation systems and to provide general information about air movements in the general work area.

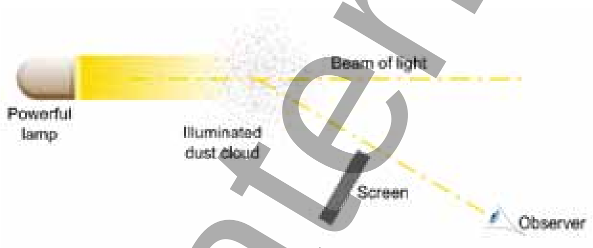
Limitations of smoke tubes:

- Do not give a quantitative measure of concentration, only a qualitative indication of air movement.
- Smoke particle size will probably be different from the size of contaminant particles, so the smoke may move in air currents in a different way.

Dust Monitoring Equipment

Dust Lamp (Tyndall Lamp)

Airborne dust in the workplace which is not visible to the naked eye can be visualised using a dust lamp.



Tyndall Beam Apparatus

A strong beam of light is shone through the area where a cloud of finely divided dust is suspected. The eye of the observer is shielded from the light beam and the dust cloud is made visible. The method is used to determine how exhaust ventilation systems are working.

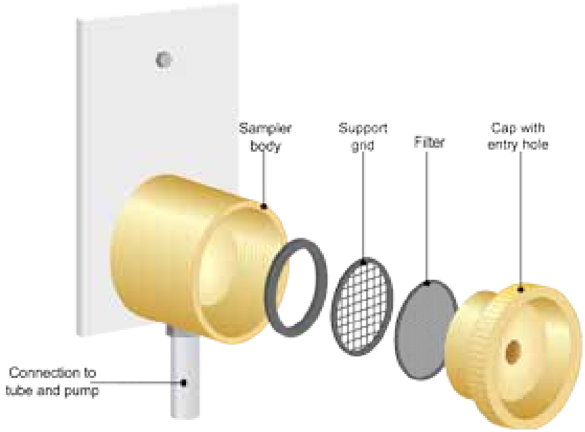
Limitations of dust lamps:

- Do not provide numerical data, only a qualitative indication.
- Provide no differentiation between contaminants and any other dusts.

Indirect-Reading Filtration Equipment

Dust exposure can be measured using a sampling train made up of an air pump, tube and sampling head. This can be worn by a worker to give a personal sample covering their work period, or placed in a static location to get a background sample.

Air is drawn through and dust is collected onto a pre-weighed filter, which is taken to a laboratory where it is weighed again and the amount of dust in the air calculated. This will be an average value over the chosen period of time.



Dust sampler head showing filter in position
(Based on original source: MDHS 14/3 General Methods for Sampling and Gravimetric Analysis of Respirable and Inhalable Dust)
(Reproduced under the terms of the Open Government Licence)

Limitations of dust samplers:

- Only suitable for calculating average exposures over long periods (minimum four hours).
- All the dust is assumed to be the contaminant dust for calculation purposes (unless more expensive analysis is carried out).
- Easy to misuse.

Revision Questions

5. Identify the routes of entry of chemicals into the body.
6. What is the difference between an inhalable substance and a respirable substance?
7. What information is generally provided on the product label of a substance that is classified as dangerous for supply?
8. What is the purpose of safety data sheets?
9. What is the difference between passive and active sampling devices?
10. Give three limitations in the use of stain tube detectors.
11. What are smoke tubes used for?

(Suggested Answers are at the end of Unit ICC1.)

Occupational Exposure Limits

Key Information

- Occupational exposure limits (OELs) are maximum concentrations of airborne contaminants, normally measured across a particular reference period of time, to which employees may be exposed (usually by inhalation).
- Short-term exposure limits combat the sudden, acute effects of exposure; long-term exposure limits combat the long-term chronic effects.
- There are limitations to the effectiveness of occupational exposure limits in ensuring that employees are not exposed to harmful levels of hazardous substances.
- The way that exposure limits are determined differs internationally, and methods of harmonising these are being tried.

Purpose of Occupational Exposure Limits

The purpose of OELs is to put a ceiling in place so that employees will not be exposed to the inhalation of high concentrations of airborne substances (either for short durations of time or for long periods of the working day) where scientific evidence suggests that there is a risk to their health. Such limits are determined by national or local regulations, and allow employers to achieve adequate control for most substances that are assigned an OEL by applying principles of good practice and ensuring that the OEL is not exceeded on a time-weighted average basis (see later).

However, in certain situations a stricter level of control may be required by national or local law. For carcinogens, mutagens and sensitising agents capable of causing occupational asthma, for instance, employers must ensure that the control measures in place reduce employee exposure not just to below the OEL but as far below the OEL as is reasonably practicable.

Application of Relevant Limits

Occupational exposure limits are called different things (TLVs, WELs, etc.) in different parts of the world, but they are all occupational exposure limits.

How the limits are applied is important to the construction manager, so that he can ensure that limits are not exceeded. As part of the risk assessment, measurement of the airborne concentrations of substances will show how much there is in the air. If this is below the limits, no further controls will be necessary. If the concentration is over the limits, the manager must decide if a safer substance can be used instead – perhaps one with lower limits. If not, then other control options must be considered so that workers do not suffer ill-health from inhaling the airborne concentrations of these substances (we will look at a hierarchy of controls later).

Threshold Limit Values

TLVs are limits set (mainly) by the ACGIH in the United States of America, and are guidelines to help in determining safe levels of exposure to breathing hazardous substances, purely based on health factors. They are published and available in a handbook.

Workplace Exposure Limits

WELs are again maximum concentrations of airborne contaminants, listed in the UK HSE publication *EH40: Workplace Exposure Limits* which is updated by annual supplements. EH40 also provides detailed guidance on the use of WELs.

Maximum Allowable Concentrations

MACs are another form of limit, again used mainly in the USA. They can refer to the maximum allowable concentration of a gas, vapour, spray or substance; they are also used with concentrations of biologically active physical or chemical agents. MACs refer to the concentration in the air at the place of work which remains generally without harmful effects when exposed over an 8-hour day, 40 hours a week through the working life.

Topic Focus

Units of Measurement of Exposure

The two main units used for measuring airborne concentrations are:

- Parts per million (ppm).
- Milligrams per cubic metre of air (mg/m^3, or $mg\ m^{-3}$).

Vapours and gases are measured in ppm, which refers to the number of parts of vapour or gas of a substance in a million parts of air by volume. Particulate matter - dusts, fumes, etc. - is measured in mg/m^3, which refers to the milligrams of the substance per cubic metre of air.

One further unit of measurement is used in relation to fibres (e.g. asbestos):

- Concentrations of fibres are expressed in fibres per millilitre of air (fibres ml^{-1}).

Long-Term and Short-Term Limits

Occupational exposure limits are usually time-weighted average (TWA) exposures, i.e. they are calculated by measuring a person's average exposure over a specific reference period of time.

The two reference periods commonly used are:

- **15 minutes** – short-term exposure limit.
- **Eight hours** – long-term exposure limit.

The reasons for having two limits are:

- **Short-Term Exposure Limits (STEL)** combat the ill-health effects (acute effects) of being exposed to very high levels of the substance for quite short periods of time.
- **Long-Term Exposure Limits (LTEL)** combat the ill-health effects of being exposed to relatively low concentrations of a substance for many or all hours of every working day throughout a working lifetime (chronic effects).

Limitations of Exposure Limits

Occupational exposure limits are designed to control the absorption into the body of harmful substances after they have been inhaled. They are not concerned with absorption from swallowing or through contact with the skin or eyes. So they will not take into account high levels of solvent that are present in a person who has had skin contact with it for a period of time – only that which they have inhaled.

They take no account of human sensitivity or susceptibility. This is particularly important in the case of substances which produce an allergic response – once a person has become sensitised, the exposure limit designed to suit the average person has no further validity.

- They do not take account of the synergistic (combined) effects of mixtures of substances, e.g. the use of multiple substances.
- They do not provide a clear distinction between "safe" and "dangerous" conditions.
- They cannot be applied directly to working periods which exceed eight hours.
- They may become invalid if the normal environmental conditions are changed, e.g. changes in temperature, humidity or pressure may increase the harmful potential of a substance.

Principle of Reducing Exposure Levels

- The operation of OELs is based on controlling risk by reducing the workplace exposure to the contaminant. National or local regulations will therefore require that exposure to harmful substances should be reduced to the lowest level reasonably practicable.
- Eliminating exposure is the best way to control risk. Although this has generally been adopted for certain chemicals (e.g. carcinogens), it is impractical in most situations when we take into account the requirements of working processes. Limitation of the risk therefore becomes the next best strategy.
- In practice, reducing exposure may mean more than simple compliance with the stated OEL. Under national and local regulations, if it is reasonably practicable to get contamination levels even lower, then that standard should be achieved.

International Variations and Attempts at Harmonisation

EU Indicative Limit Values

Other exposure limits are to be found in the EU List of Indicative Limit Values (Europe), which attempts to bring about some level of harmonisation throughout member states regarding such exposure limits.

Revision Questions

12. What is an occupational exposure limit (OEL)?
13. What do you understand by the term 'time-weighted average' in relation to an OEL?
14. Give three examples of the limitations of OELs.
15. What two reference periods are commonly used with TWAs?

(Suggested Answers are at the end of Unit ICC1.)

Control Measures

Key Information

- Exposure to hazardous substances should be prevented or, if not possible, controlled to below the occupational exposure limits.
- There are Principles of Good Practice as regards the control of exposure: minimisation of emissions; consider routes of exposure; appropriate controls; use of PPE; checks on effectiveness of controls; provision of information and training.
- Measures to achieve the Principles of Good Practice include: eliminate or substitute the substance; change the process; reduce exposure time; enclose or segregate; local exhaust ventilation; dilution ventilation; respiratory protective equipment; other PPE; personal hygiene; health surveillance.
- Further controls may be required for substances that can cause cancer, asthma or damage to genes that can be passed from one generation to another.

Duty to Prevent Exposure

Article 28 (Health Hazards) in the **ILO Safety and Health in Construction Convention 1988 C167** revision of the safety provisions for construction requires an employer to prevent exposure to substances hazardous to health if it is reasonably practicable to do so. It states:

"1. Where a worker is liable to be exposed to any chemical, physical or biological hazard to such an extent as is liable to be dangerous to health, appropriate preventive measures shall be taken against such exposure.

2. The preventive measures referred to in paragraph 1 above shall comprise –

(a) the replacement of hazardous substances by harmless or less hazardous substances wherever possible; or

(b)technical measures applied to the plant, machinery, equipment or process; or

(c) where it is not possible to comply with subparagraphs (a) or (b) above, other effective measures, including the use of personal protective equipment and protective clothing."

Adequately Control Exposure

If prevention is not reasonably practicable, exposure is to be **adequately controlled**. This will require putting in place measures appropriate to the activity and consistent with the risk assessment, following the hierarchy of controls.

Jargon Buster

"Adequate control"

Adequate control of exposure to a substance hazardous to health means:

- Applying the eight principles of good practice (see below);
- Not exceeding the OEL for the substance (if there is one); and
- If the substance causes cancer, heritable genetic damage or asthma, reducing exposure to as low as is reasonably practicable.

Ensuring OELs are Not Exceeded

The HSE (UK) and ACGIH (USA), as well as European and other national and local competent authorities have established OELs for a number of substances hazardous to health. These are intended to prevent excessive exposure to the substance by containing exposure to below a set limit. Correctly applying the Principles of Good Practice will mean exposures are controlled below the OEL.

Topic Focus

The **eight Principles of Good Practice** are:

- **Principle 1** - Design and operate processes and activities to minimise emission, release and spread of substances hazardous to health.
- **Principle 2** - Take into account all relevant routes of exposure – inhalation, skin and ingestion – when developing control measures.
- **Principle 3** - Control exposure by measures that are proportional to the health risk.
- **Principle 4** - Choose the most effective and reliable control options that minimise the escape and spread of substances hazardous to health.
- **Principle 5** - Where adequate control of exposure cannot be achieved by other means, provide, in combination with other control measures, suitable PPE.
- **Principle 6** - Check and review regularly all elements of control measures for their continuing effectiveness.
- **Principle 7** - Inform and train all employees on the hazards and risks from substances with which they work, and the use of control measures developed to minimise the risks.
- **Principle 8** - Ensure that the introduction of measures to control exposure does not increase the overall risk to health and safety.

Control Measures Used to Implement the Principles of Good Practice

Elimination or Substitution of Hazardous Substances

It may be possible to eliminate or substitute the substance by:

- Eliminating the process or type of work that requires the use of (or creates) the substance (e.g. outsourcing a paint-spraying operation).
- Changing the way that the work is done to avoid the need for the substance (e.g. screwing items together rather than gluing).
- Disposing of unused stock of substances that are no longer needed.
- Substituting the hazardous substance for one non-hazardous (e.g. switch from an irritant to a non-hazardous floor cleaner).
- Substituting a hazardous substance for one that has a lower hazard classification (e.g. exchange a solvent paint for a water-based paint).
- Changing the physical form of a substance (e.g. use pellets instead of powder).

Process Changes

It may be possible to change a process so that risks can be reduced, e.g.

- Brush painting rather than spraying reduces airborne mist and vapour.
- Vacuuming, rather than sweeping up, reduces dust levels.
- Damping of a substance during mixing or when clearing up reduces dust levels.

Reduced Time Exposure

Ill-health effects caused by hazardous substances are often related to the length of time of exposure and the dose (amount) of the contaminant. Reducing the time will reduce the dose (extending the time increases the dose). We should therefore look to minimise the time people work with hazardous substances, especially with those having acute effects. If a short-term exposure limit (15-minute TWA) exists for the substance, this must not be exceeded. We can achieve this by:

- Providing for regular breaks away from contact with the hazardous substance.
- Job rotation – where exposure of an individual is reduced by sharing the dose with other workers.

Enclosure and Segregation

Where it is not possible to reduce exposure, then we have to consider physical controls which enclose the hazard and segregate people from the process involving it.

Total enclosure of a process which generates dust or fumes will prevent the escape of airborne contaminants which could be inhaled by operators nearby. However, it may still be necessary to access equipment or material within that area, so the use of robotically-controlled, remote handling systems may be incorporated, allowing access without disturbing the integrity of the enclosure.

Where isolation of the source is difficult, it may be more practical to enclose the workers to ensure that they remain segregated from the hazard (e.g. in a control booth).

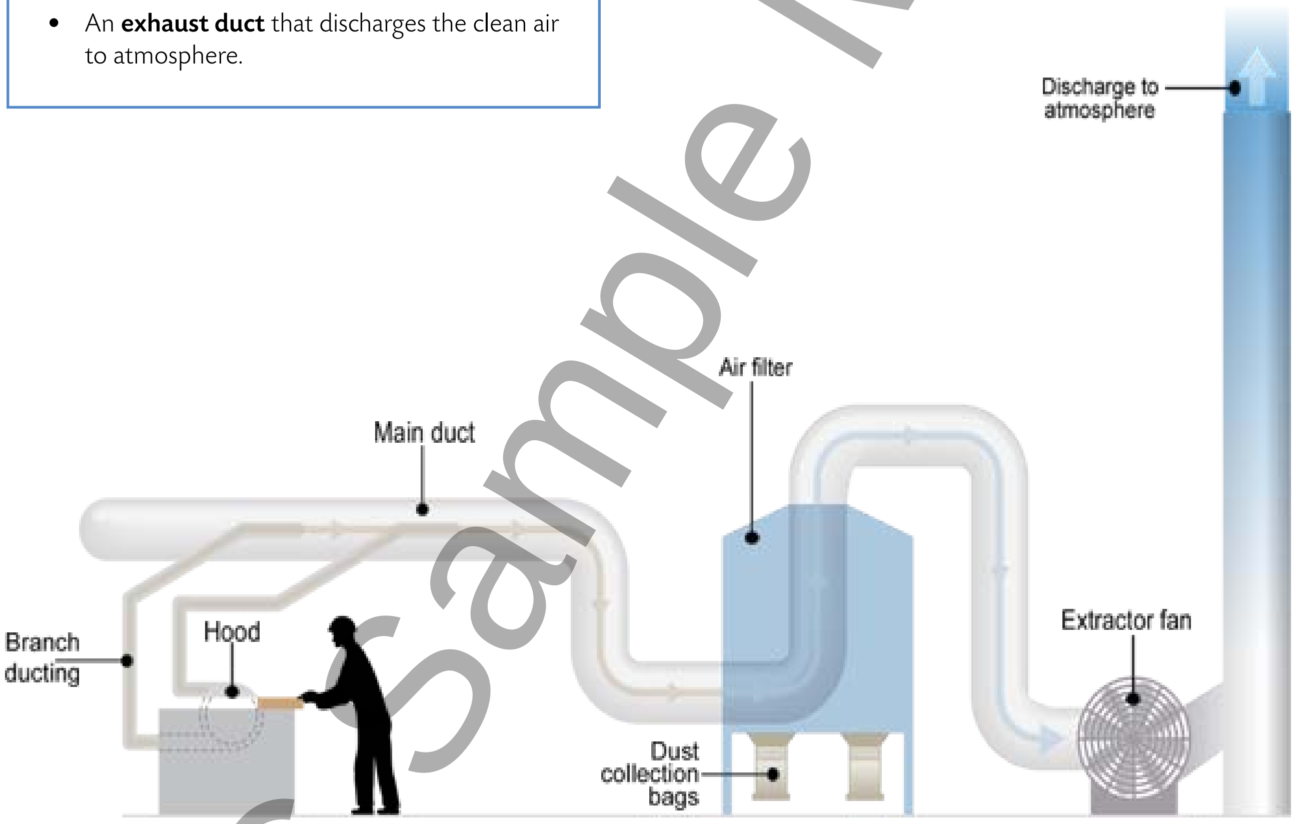
Local Exhaust Ventilation (LEV)

This will contain and collect dusts, vapours and fumes where they are generated, and prevent them spreading further into the workplace. The contaminants will be filtered out and the clean air exhausted outside the workplace.

Topic Focus

A **typical LEV system** consists of:

- An **intake hood** that draws air containing the contaminant in at the point it is created.
- **Ductwork** that carries the air from the intake hood.
- A **filter system** that cleans the contaminant from the air to an acceptable level.
- A **fan** that provides the air movement through the system.
- An **exhaust duct** that discharges the clean air to atmosphere.



A typical LEV system extracting sawdust from a bench-mounted circular saw

Examples of LEV include:

- **Glove boxes** – total enclosures, often used in laboratories, accessed through flexible gloves and kept under negative pressure to prevent any release of contaminant.
- **Fume cupboards** – partial enclosures, again used in laboratories, accessed through a vertical sliding sash, with the enclosure kept under negative pressure so that the air flow is through the sash into the hood to prevent any release of contaminant.
- **Captor hoods** – hoods which can be positioned as near as possible to the hazard and capture contaminants by a negative air flow into the hood before they reach the operator, e.g. those used to extract woodworking dust or welding fume.
- **Receptor hoods** – large structures designed to capture contaminants which are being directed naturally into the hood, so that less air movement is needed to achieve uptake (e.g. a large intake hood above a bath of molten metal - the metal fume will be hot and rising up into the hood on convection currents).

Factors that Reduce Effectiveness

- Poorly positioned intake hoods.
- Damaged or leaking ducts.
- Excessive amounts of contamination.
- Ineffective fan due to slow speed or lack of maintenance.
- Blocked filters.
- Build-up of contaminants in the duct.
- Sharp bends in the duct.
- Unauthorised additions into the system.

Inspection and Monitoring

LEV systems must be routinely inspected and maintained to ensure their continuing effectiveness.

- **Regular Visual Inspections**

  Check:

  – The integrity of the system, and for signs of obvious damage and build-up of contaminant inside and outside the ductwork.
  – Filters, to ensure they are not blocked (some have a collector can which can be emptied).
  – The exhaust outlet is clear.
- **Planned Preventive Maintenance**

  May include:

  – Replacing filters.
  – Lubricating fan bearings.
  – Inspecting the fan motor.
- **Periodic Testing**

  – Ensure that air velocities through the system remain adequate.
  – Can be done by visual inspection of the captive system using a smoke-stick, measuring air velocity at the intake and along the ductwork using an anemometer, and measuring static pressures with manometers and pressure gauges.

LEV provided as a control measure for hazardous substances should be thoroughly examined by a competent person every 14 months.

Dilution Ventilation

This operates by diluting the contaminant concentration in the general atmosphere to an acceptable level, by efficiently changing the air in the workplace over a given period of time, e.g. a number of complete changes every hour.

The air changes might be achieved:

- **Passively** – by providing low-level and/or high-level opening louvres.
- **Actively** – using powered fans.

This type of ventilation is intended to be effective in removing gas contaminants (sometimes fumes) and to keep overall concentration of any contaminants below the OEL.

Dilution ventilation is appropriate where:

- The OEL of the hazardous substance is high.
- The rate of formation of the gas or vapour is slow.
- Operators are not in close contact with the contamination generation point.

If a powered system is used, fans must be sited appropriately. If the contaminant is:

- **Lighter** than air, it will naturally rise up inside workrooms and be extracted at high level.
- **Heavier** than air, it will sink to the floor and low-level extraction will be more suitable.

Limitations of dilution ventilation systems:

- Not suitable for the control of substances with high toxicity.
- Do not cope well with sudden releases of large quantities of contaminant.
- Do not work well:
  – On dust.
  – Where the contaminant is released from one point source.
- Dead areas may exist where high concentrations of the contaminant are allowed to accumulate.

Dead areas are those areas in a workplace which remain dormant so the air in them is not changed. This is usually due to the air-flow patterns produced by poor positioning of extraction fans and inlets for make-up air. Dead areas can move from one place to another as a result of changing the positions of fans and make-up air inlets, or by the intrusion of other air through windows and doors. Moving the position of machinery or workbenches can have similar effects.

Respiratory Protective Equipment (RPE)

Jargon Buster

Respiratory protective equipment (RPE)

Any type of PPE specifically designed to protect the respiratory system, e.g. self-contained breathing apparatus.

Purpose and Application

The general principles of PPE can be applied to RPE, in that it is worn by workers to reduce the possibility of harm from exposure to a hazardous substance. This is called a safe person strategy. Ideally, the **safe person strategy** is a second line of defence against a potential hazard – control at source, or a **safe place strategy**, should be the first aim.

There will be situations where personal protection is the most appropriate method to deal with a particular hazard, e.g. when the cost of controlling the hazard at source is high and the time required for protection is short. Classic situations which typify these conditions are:

- Work involving planned maintenance, e.g. during plant shut-downs.
- One-off tasks generating airborne contaminants, e.g. demolition of a building by pulling it down.
- Failure of primary safety systems or emergency situations, e.g. a chemical leak from an on-site storage tank.

Types of RPE and their Effectiveness

There are two main categories of RPE:

- **Respirators** - designed to filter the air from the immediate environment around the wearer.
- **Breathing apparatus** - provides breathable air from a separate source.

The following is a description of the different types of equipment and their effectiveness.

Respirators

These come in a variety of types:

- **Filtering Face-Piece Respirator**

  This is the simplest type, consisting of a piece of filtering material worn over the nose and mouth and secured by elastic headbands. Fit around the chin and face depends on the tension in the headbands; a flexible metal strip enables the user to bend it over the bridge of the nose to ensure a personal fit.

A worker using a filtering face-piece respirator to prevent inhalation of wood dust

This type of respirator is useful to prevent inhalation of dust or fibres (and sometimes gas and vapours), but is not suitable for high concentrations of contaminant, for use against substances with high toxicity, or for long duration use.

Use and benefits	Limitations
Cheap	Low level of protection
Easy to use	Does not seal against the face effectively
Disposable	Uncomfortable to wear

- **Half-Mask or Ori-Nasal Respirator**

  This is a flexible rubber or plastic face-piece which covers the nose and mouth, with one or two filtering canisters (cartridges) that contain the filtering material. It gives a much higher level of protection than the filtering face-piece respirator.

A worker wears a half-mask respirator to seal asbestos lagging around a pipe

Use and benefits	Limitations
Good level of filtration	No built-in eye protection
Good fit achievable	Negative pressure inside face-piece
Easy to use	Uncomfortable to wear

When the wearer inhales, a negative pressure is created inside the face-piece; this means that any leak in the respirator or around the seal will allow contaminants in.

- **Full Face Respirator**

  This is similar to the half-mask (also with canister filters) but has a built-in visor that seals in the eyes and face. This type gives a high level of protection against airborne contaminants and protects the eyes, which can be important where contaminants may splash or can cause irritation or be absorbed through the eyes.

A full face respirator with filtering canister (or cartridge)

Use and benefits	Limitations
Good level of filtration	Restricts vision
Good fit achievable	Negative pressure inside face-piece
Protects the eyes	Uncomfortable to wear

- **Powered Visor Respirator**
  - A powered fan blows filtered air to the wearer.
  - Usually made up of a helmet and face visor, with the air drawn in through a filter in the helmet, and fed down over the face inside the face-piece.
  - Powered by rechargeable battery.

  This type of respirator does not have a tight seal around the face, and is especially suited to dusty, hot environments where the stream of air moving over the face is a benefit. Similar is the **powered clean air respirator** which has the filter remote from the visor, usually worn on the belt, and fed to the visor through a tube.

Use and benefits	Limitations
Intermediate level of filtration	Heavy to wear
Air movement cools wearer	No tight face seal
Air stream prevents inward leaks	Limited battery life

Powered Visor Respirator

Breathing Apparatus (BA)

This can be classified under three general headings:

- **Fresh-Air Hose BA**

  This is the simplest type, where a large diameter hose is connected to the user's face mask. Air is either drawn down the hose by breathing or blown down by a low speed/low pressure fan.

Use and benefits	Limitations
Air is from outside the work room	Hose must be tethered
Supply of air is not time-restricted	Bends or kinks make breathing difficult
	User is restricted by limited hose length

- **Compressed Air BA**

  Similar to the fresh-air hose BA, but air is supplied through a small-bore hose at high pressure. Pressure is stepped-down by a regulator and supplied at low pressure to the user's face mask.

Use and benefits	Limitations
Supply of air is not time-restricted	Hose can be long, but not endless
Positive pressure inside face-piece	
Wearer is not burdened with cylinder	

- **Self-Contained Apparatus**

  Breathable air is supplied from a pressurised cylinder worn by the user. This type of BA gives the wearer complete freedom of movement, but it is the most heavy and bulky type. The air cylinder does have a limited capacity.

A firefighter wearing self-contained breathing apparatus and other personal protective equipment

Use and benefits	Limitations
Complete freedom of movement	Supply of air is time-restricted
Positive pressure inside face-piece	Equipment is bulky and heavy
	More technical training is required

Selection, Use and Maintenance

RPE must be selected carefully to ensure that it is suitable.

Topic Focus

Key factors in the selection of RPE:

- Contaminant concentration and its hazardous nature (e.g. harmful, toxic).
- Physical form of the substance (e.g. dust, gas, vapour).
- Level of protection offered by the RPE.
- Presence or absence of normal oxygen concentrations.
- Duration of time that it must be worn.
- Compatibility with other PPE that must be worn.
- Shape of the user's face and influences on fit.
- Wearer acceptability.
- Facial hair might interfere with an effective seal.
- Physical requirements of the job, e.g. the need to move freely.
- Physical fitness of the wearer.

The level of protection offered by an item of RPE is usually expressed as the **Assigned Protection Factor (APF)**. This is a measure of how well the RPE keeps out the contaminant and is given by the formula:

$$\text{APF} = \frac{\text{Concentration of contaminant in workplace}}{\text{Concentration of contaminant in face-piece}}$$

Any RPE selected must meet the relevant standards (e.g. CE marked).

Users of RPE should receive appropriate information, instruction and training. In particular they should:

- Understand how to fit the RPE.
- Have a face-fit test to ensure suitability and fit.
- Know:
  - How to test the item during use to ensure it is working effectively.
  - The limitations of the item.
  - Any cleaning requirements.
  - Any maintenance requirements (e.g. how to change the filter).

Maintenance and cleaning of RPE must be carried out in accordance with the manufacturers' instructions and any national or local legal requirements (e.g. requirements for keeping a record of inspections, replacement parts, etc.). This should include the need to repair or replace worn or damaged items. Maintenance should be carried out by trained, competent personnel.

Other Protective Equipment and Clothing

There are other types of PPE used to protect from exposure to hazardous substances.

Gloves

Gloves (short cuffs) and gauntlets (long cuffs) can give protection against:

- Chemicals such as acids, alkalis, solvents, oils (e.g. corrosive cement).
- Biological agents such as blood viruses and body fluids.
- Physical agents such as contaminated dusts, and cuts from contaminated blades or syringes.
- Water – even uncontaminated water can soften and damage the skin of someone exposed for long periods.

For protection against chemicals it is important to ensure the gloves are of the right material impervious to the chemical.

Overalls

"Ordinary" overalls are not regarded as PPE, but "work wear" - in that they are not commonly intended to do more than keep a person (and their clothing) clean. However, even overalls can offer some level of protection against everyday construction contaminants such as soil, clay, oils and grease.

There are items of PPE intended to protect the construction worker from hazards:

- Flame-retardant overalls.
- Chemical-resistant overalls – protect from acids, alkalis, etc.
- Disposable coveralls (hooded) - worn in asbestos removal and impervious to the passage of extremely fine fibres.
- Aprons – prevent spills and splashes from soaking into normal work wear and the skin.

Eye Protection

Different types of eye protection common in construction activities include:

- **Spectacles:**
  - Offer a degree of front and side protection but do not completely encase the eyes.
  - Mainly for impact protection from flying objects and debris.
- **Safety goggles:**
  - Completely encase the eyes with protection from impact, chemical gas, liquid splashes and molten metal.
- **Face shields:**
  - Cover the eyes and face, but do not enclose them.
  - Limited protection from impact and splashes.
- **Hoods and visors:**
  - Offer all-round enclosed protection, especially from liquid splashes to the face.

Safety Helmets

Protection from falling or moving objects on a construction site is required, regardless of exposure to hazardous substances.

Safety Footwear

This not only offers protection to the toes, but some may be chemical-resistant where exposure to spillages or contaminated ground may occur.

Personal Hygiene and Protection Regimes

Personal hygiene goes a long way to preventing absorption of hazardous substances into the body, by preventing contact in the simplest of situations. Many chemical and biological agents get into the body from the skin of the hands, into the mouth and eyes from cross-contamination. Likewise, food, drink and cigarettes all offer the same opportunity.

Good hygiene means:

- **Hand washing** when leaving the work area, and always before eating, drinking or smoking.
- **Careful removal** and disposal of potentially contaminated items of PPE to prevent cross-contamination to normal clothes and the skin.
- **Prohibition** of eating, drinking and smoking in work areas.

All construction sites must have adequate welfare facilities (water, soap and a means for drying). With more serious hazards, showers and nail brushes may be required. Barrier creams may also prove useful.

Facilities should be provided to:

- Change and store clothing and PPE.
- Store, prepare and consume food and drinks.

In some situations **vaccinations** may protect workers from biological agents:

- Vaccination against hepatitis B is often offered to first-aiders.
- Those working near water may gain some protection from immunisation against Weil's disease.

Issues to consider before embarking on a vaccination programme:

- Worker consent must be obtained.
- Vaccination does not always grant immunity.

- Vaccination can give workers a false sense of security.

In most cases vaccination should only be offered when indicated by law or codes of practice.

Health Surveillance

The purpose of routine health surveillance is to identify, at as early a stage as possible, any variations in the health of employees which may be related to working conditions.

Two types of health surveillance are commonly carried out:

- **Health monitoring** – where workers are examined for symptoms and signs of disease that might be associated with a particular agent they are exposed to in their work, e.g. those working in the dustiest areas of a site or cement production may have lung-function tests (spirometry) to check for respiratory disorders.
- **Biological monitoring** – where a blood, urine or breath sample is taken and analysed for the presence of an agent or its breakdown products, e.g. those working with lead processes might have blood samples taken to check for cumulative levels of lead in the blood.

In certain circumstances, **pre-employment health screening** may be appropriate to establish a "baseline", and then periodically to monitor for changes. The need for some health surveillance is subject to legislation.

Further Controls for Carcinogens, Asthmagens and Mutagens

Exposure to substances that can cause cancer, asthma or damage to genes that can be passed from one generation to another should be prevented. If this is not possible, a hierarchy of controls should be adopted:

- Totally enclosing the process and handling systems.
- Prohibition of eating, drinking and smoking in contaminated areas.
- Regular cleaning of floors, walls and other surfaces.
- Designation of areas that may be contaminated with warning signs.
- Safe storage, handling and disposal.

Revision Questions

16. What principles of control are illustrated by the following measures?
    (a) Using granulated pottery glazes instead of powders.
    (b) Vacuum cleaning rather than sweeping with a broom.
    (c) Job rotation.
    (d) Using water-based adhesives rather than solvent-based ones.
17. What is the difference between local exhaust ventilation and dilution ventilation?
18. What are dead areas, and why are they a problem for dilution ventilation?
19. List four main types of respirator and the three main types of breathing apparatus.
20. What are the key criteria in the selection of the appropriate respirator to use?
21. What is the main purpose of routine health surveillance?

(Suggested Answers are at the end of Unit ICC1.)

Specific Agents

Key Information

- Specific hazardous agents may be encountered in construction work that can cause ill-health to workers exposed, such as blood-borne viruses, organic solvents, carbon dioxide, nitrogen, isocyanates, lead, carbon monoxide, cement, legionnaires disease, Weil's disease, silica, fibres, hepatitis, tetanus and hydrogen sulphide.
- Construction workers can also be exposed to a number of dusts in their everyday work, e.g. cement dust and wood dust.
- Asbestos can still be found in older buildings.
- Systems must be in place to:
  - Identify the presence of asbestos.
  - Protect workers.
  - Remove and dispose of asbestos.

Hazards, Risks and Controls – Specific Agents

The following are some chemical and biological agents commonly encountered in construction activities, with a description of their health effects.

Blood-Borne Viruses

Blood-borne viruses are carried in the blood stream of an infected person, but are not easily transmitted to others unless their blood comes into contact with the broken skin of another person. Such viruses include HIV (human immunodeficiency virus) which causes AIDS (acquired immune deficiency syndrome) and Serum Hepatitis (hepatitis B - see later).

Exposure to blood-borne viruses usually comes from contact with blood from injured persons being treated by a first-aider at work, or from unintentional contact with discarded items such as needles ("sharps injuries" and "needle-stick" injuries).

Typical controls include:

- Use of gloves and eye protection when handling potentially contaminated material.
- Correct collection and disposal of potentially contaminated material.
- Preventing needle-stick injuries by correct collection and disposal of sharps in a sharps container.
- Vaccination where appropriate.
- Procedures to deal with accidental exposures (e.g. needle-stick injury).

Petrochemicals

Petrol, diesel, oils and greases are used in construction machinery. Skin contact causes de-fatting and can lead, over a period of time, to dermatitis.

Organic Solvents

These are found in many materials used in construction, e.g. paints, varnishes, adhesives, pesticides, paint removers and cleaning materials. The most common organic solvents used in the construction industry are:

- White spirit – in paints, varnishes and cleaning products.
- 1-Butanol – in paints, lacquers, and natural and synthetic resins.
- Toluene and xylene:
  - Common ingredients in paints.
  - Used as degreasers and cleaners to remove oils, etc. from metal components.

Exposure to them may result in irritation and inflammation of the skin, eyes and lungs, causing dermatitis, burns and breathing difficulties. Vapours given off are usually flammable, and may be narcotic (e.g. toluene) progressively causing drowsiness, nausea and unconsciousness. Some organic solvents are carcinogenic.

Typical controls include:

- Avoiding inhalation of vapours (e.g. well-ventilated work areas or use of RPE).
- Avoiding skin contact by correct use of gloves and protective clothing.

- Never use solvents to wash the skin.
- Procedures to ensure correct storage and handling of solvents.
- Procedures to deal with spillages and collection and disposal of waste materials.

Carbon Dioxide

This is a colourless, odourless gas that is heavier than air. When anything organic is burned, carbon dioxide (CO_2) is produced. Road vehicles produce 20% of the UK's CO_2 emissions. CO_2 is used extensively for fire-fighting.

The air that we breathe contains around 0.038% CO_2 (by volume) and 21% oxygen. When we inhale, we absorb some of the oxygen into the blood and carbon dioxide is exhaled. With a higher concentration of CO_2 in the air the body finds it difficult to get rid of its own CO_2. This can have effects that range from drowsiness (at 1% CO_2) to excessive sweating, muscle tremor and unconsciousness (8% CO_2). At above 10% unconsciousness will occur followed rapidly by asphyxiation (even with oxygen at 21%).

Typical controls include:

- Avoid burning organic materials on site.
- If unavoidable, ensure well ventilated areas are used.
- Do not leave vehicle engines running unnecessarily.
- Never park vehicles with engines running near excavations or confined spaces.

Topic Focus

Asphyxiant Gases

Gases described as "asphyxiant" (e.g. carbon dioxide (CO_2), carbon monoxide (CO)) do not cause direct injury to the respiratory tract when inhaled, but reduce the oxygen available to the body.

CO_2 is a simple asphyxiant which displaces air, whereas CO is a chemical asphyxiant which combines with haemoglobin to form a compound which prevents oxygen transport by the blood.

Nitrogen

Nitrogen is a gas that takes up 80% of the air we breathe. It is one of a number of gases that can be used for inerting (others are carbon dioxide, argon and helium). The major risk associated with use of inerting is that of asphyxiation, particularly in confined spaces. Nitrogen is also used in pipe-freezing.

Typical controls include:

- Procedures in place for confined space entry.
- Safe systems of work and trained persons to employ inerting processes.

Jargon Buster

Inerting

Where an "inert" gas (nitrogen) is used to suppress a flammable atmosphere, e.g. in a fuel tank, to prevent explosion.

Carbon Monoxide

Carbon monoxide (CO) is a colourless, odourless, tasteless gas. It is found in combustion gases such as coal gas, car exhaust, producer gas, blast-furnace gas and water gas.

CO is toxic. It combines with haemoglobin in the blood, impairing the transportation of oxygen. Concentrations above 5% cause immediate loss of consciousness, but far more people are killed by exposure to much lower concentrations over a period, typically when a gas-fired heater is used in a poorly ventilated room.

Typical controls include:

- Restrict work on gas systems to competent engineers only.
- Maintenance and testing of boilers and flues.
- Good workplace ventilation.
- LEV for vehicle exhausts in workshops.
- Care in the siting of plant run by internal combustion engines.
- Carbon monoxide alarms.
- Confined space entry controls.

Isocyanates

These are organic compounds used to make adhesives, synthetic rubber, foams and paints (particularly 'two-pack' paints). They are liquid at normal temperature but evaporate slowly.

They are hazardous by inhalation and skin contact, possibly leading to sensitisation. Once this has occurred, further exposures may cause severe allergic dermatitis and chronic asthma.

Typical controls include ensuring:

- Risk assessment carried out and safety data sheet available.
- Adequate ventilation in all areas of use.
- Hygiene practices prevent skin contact.

Lead

Lead is a soft heavy metal often used in roofing materials and is relatively inert. Lead compounds can be categorised into:

- **Inorganic compounds** such as lead oxide (red lead) and lead chromate (chrome yellow) used as pigments, though because of toxicity no longer in paints for domestic use.
- **Organic lead** which was extensively used as an anti-knock agent in petrol (lead tetraethyl), but has now mostly been replaced because of health concerns.

Both can be hazardous by inhalation and ingestion (organic lead is more readily absorbed by both routes). When inhaled or ingested, lead is a cumulative toxin which builds up over time. It has symptoms such as muscle tremors, anaemia (low red blood cell count) and brain damage. It can cause miscarriage and birth defects during pregnancy.

Typical controls include:

- Eliminating or reducing exposure.
- Use of work clothing, and PPE such as gloves, dust masks.
- Good hygiene practices.
- Biological monitoring for lead absorption (blood or urine sampling).

Fibres

Two types of material encountered in construction that are fibrous:

- **Machine-Made** (formerly "Man-Made") **Mineral Fibres** (MMMF) – classically "rockwool" and slag wool are used for thermal and acoustical insulation in the construction industry. MMMF products release airborne respirable fibres during production and use.
- **Asbestos** – a group of naturally occurring minerals that have been used extensively as fire-resistant building, lagging and insulating materials. The three main types are blue, brown and white asbestos. We will look at asbestos in more detail later.

Silica

Silica is a compound present in many rocks and stones, particularly sandstone, quartz and slate, and found in ceramics (e.g. clay pipes) and cement. It is hazardous when inhaled as a dust and can cause numerous chest and respiratory tract diseases. The most common is where silica is deposited deep in the lungs, causing scar tissue to form (silicosis) very similar to asbestosis.

Typical controls include:

- Prevention of exposure by use of alternative work methods.
- Dust suppression by use of water sprays or jets.
- Local exhaust ventilation.
- Respiratory protective equipment.
- Health surveillance (spirometry and chest X-ray).

Cement Dust and Wet Cement

Cement is widely used in construction, e.g. mortar, plaster and concrete, and presents a hazard to health in a number of ways, mainly by skin contact and inhalation of dust.

- Contact with wet cement can cause both dermatitis and burns.
- Cement is capable of causing dermatitis by irritancy and allergy.
- Both irritant and allergic dermatitis can affect a person at the same time.
- Wet cement can cause burns due to its alkalinity.
- Serious chemical burns to the eyes can also be caused following a splash of cement.

Cutting concrete creates high levels of cement and silica dust

Typical controls include:

- Eliminating or reducing exposure.
- Use of work clothing, PPE such as gloves, dust masks and eye protection.
- Removal of contaminated clothing.
- Good hygiene and washing on skin contact.
- Health surveillance of skin condition to control chrome burns and dermatitis.

Leptospirosis (Weil's Disease)

This is a zoonotic disease caused by Leptospira bacteria. Rats are the primary cause (from their urine deposits) but it can be found in mice, cattle and horses. The primary routes of infection are by swallowing contaminated water or food, and through cuts and grazes. Persons at risk include canal workers, sewer workers, rat catchers and agricultural workers.

Leptospirosis starts with flu-like symptoms – fever, headache and muscle pain – then progresses to a more serious jaundice-like phase. At this stage it can cause liver damage. It can be immunised against and if diagnosed early can be successfully treated. If left, it can be fatal.

Typical controls include:

- Preventing rat infestation by good housekeeping and pest control.
- Good personal hygiene (e.g. hand-washing).
- PPE (especially gloves).
- Covering cuts and grazes.
- Issuing workers with an "at risk" card to be shown to doctors to help early diagnosis.

Jargon Buster

Zoonotic diseases (zoonoses)

Diseases which originate in animals and can be passed to humans (e.g. rabies).

Legionnaires' Disease

This is caused by the water-loving soil bacterium *Legionella pneumophila*, as is Pontiac fever, a shorter, more feverish illness, without the complications of pneumonia. Legionellosis is the generic term used to cover Legionnaires' disease and Pontiac fever.

The bacteria are hazardous when inhaled in a droplet form mixed with water. This occurs in water systems such as open evaporative cooling towers, when they become contaminated with the bacteria. Water containing bacteria is sprayed inside the towers to cool, and mists drift out of the top and are inhaled by passers-by.

Legionnaires' disease developing to the pneumonia stage can often prove fatal, especially for the elderly, infirm or immuno-suppressed, and for anyone if not diagnosed early.

Typical controls include:

- Enclosing water and air conditioning systems to minimise risk of wind-drift and contamination.
- Water treatment (e.g. chlorination) to kill the bacteria.
- Operate hot water systems hotter than 60°C (the bacteria is temperature sensitive and rarely survives above 60°C).
- Use of biocides to chemically treat some water systems.
- Prevention of lime-scale build up (lime scale can harbour the bacteria).
- Water sampling and analysis.

Hepatitis

Hepatitis is a disease of the liver, caused by viral infection. There are several forms (A, B, C, etc.) caused by different strains of the virus.

- Hepatitis A is contracted orally by cross-contamination with faecal material containing the A virus, putting sewage workers at risk.
- Hepatitis B is transmitted in body fluids such as blood, putting health-care workers (and first-aiders) at risk, as well as police and fire-fighters, and waste-disposal workers.

The virus survives for long periods outside the body and can survive harsh treatments that would kill other micro-organisms (e.g. boiling water). Contaminated body fluids can cause infection by contact with damaged skin, needle-stick injuries and splashing into the eyes and mouth. Symptoms include jaundice and liver damage. Though many people are able to make a complete recovery, some will become long-term sufferers and some continue to carry the virus without displaying any of the symptoms.

Typical controls include:

- Use of gloves and eye protection when handling potentially contaminated material.
- Correct collection and disposal of potentially contaminated material.
- Preventing needle-stick injuries by correct collection and disposal of sharps in a sharps container.
- Vaccination where appropriate.
- Procedures to deal with accidental exposures (e.g. needle-stick injury).

Tetanus

The organisms causing tetanus (lock-jaw) are widespread and can gain access to the body through cuts, wounds, splinters, vegetation, contaminated soil, animal excretions, etc. Symptoms include stiffness in the muscles, a stiffening of the jaw until it is in a locked position, and breathing problems. There is a mortality rate of approximately 10%.

Typical controls include:

- Immunisation of workers to help to prevent the disease. Construction workers are susceptible when working on new sites or where there has been any agricultural activity taking place. An immunisation programme should be encouraged for any such workers.

- Use of strong gloves when handling materials that could be contaminated.
- Good hygiene and hand-washing.

Hydrogen Sulphide

Hydrogen sulphide (H_2S) (or hydrogen sulfide) is an extremely hazardous and flammable gas with the classic odour of rotten eggs. It is heavier than air, so will collect in low-lying, poorly ventilated places. It can be detected in very small amounts, but can soon deaden the sense of smell, possibly leading to high levels then going undetected. It is a chemical asphyxiant, in the same way as carbon monoxide, etc.

Unlikely to be used from cylinders in construction activities, it occurs naturally in natural gas (up to 90%), volcanoes and hot springs. Other common sources will be coal pits, sulphur springs, gas wells and areas where there is accumulation of decaying matter such as sewage and sewage treatment plants, manure stocks, swamps, ponds and areas of dead water in the sea or rivers.

The main industrial routes are petroleum refineries, coke ovens, paper mills (using sulphur) and leather tanneries.

Typical controls include:

- Monitoring of suspect areas.
- Ensuring good ventilation.
- Suitable work practices.
- Use of air-fed RPE.

More...

You may find it useful to access some of the following UK information sources:

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

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

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

Generation and Control of Dusts on a Construction Site

Silica

Because silica dust has been identified as a carcinogen and as having a link to chronic obstructive pulmonary disease (COPD), levels should be as low as reasonably practicable, and anyway below the occupational exposure limit (e.g. 0.1mg/m3 in the UK).

In employing the eight Principles of Good Practice, employers must not exceed the OEL for silica. Specific precautions should involve:

- Assessment – including air sampling.
- Eliminate silica - or substitute with other materials.
- Provide PPE – and RPE as necessary.
- Welfare facilities – for washing, changing and storing clothes on site.
- Health surveillance – for levels above 0.1mg/m3 8-hour TWA a respiratory questionnaire, lung function testing and chest X-rays should be provided.

Fibres

Machine-Made (formerly Man-Made) Mineral Fibres (MMMF) and Refractory Ceramic Fibres (RCF) are often encountered in insulating materials and exposure to inhalation of them should be prevented. LEV is not practicable in many construction activities, so the hierarchy of controls would suggest the following:

- Replace fibrous mineral materials with safer alternatives.
- Provide suitable RPE.
- Fibrous mineral materials will also have a physical irritation hazard, so protective clothing, gloves and suitable eye protection should be used.
- Good housekeeping regimes and work practices will help to reduce fibres settling that can become airborne dusts.

Asbestos

This is a mineral of fibrous nature, capable of causing asbestosis, lung cancer and mesothelioma from inhalation, as we saw earlier. It has exceptional heat insulating qualities. Its use may be banned in some countries (e.g. the UK), but it may still be found in older properties, where it is required to be managed. The biggest danger in construction is unwittingly locating asbestos during demolition or refurbishment work involving installation and even minor repairs.

We will look at methods for controlling of exposure to asbestos later in this element.

Cement

Cement is used extensively to make mortar and concrete. In its dry powder form it is an irritant dust easily inhaled or blown into the eyes. Once mixed with water it is corrosive on skin and eye contact.

Topic Focus

Construction workers can be exposed to cement during:

- **Emptying and disposing of bags** – in dry powder form.
- **Mixing cement** – in both dry powder and mixed wet forms.
- **Brick and block laying** – in the wet form.
- **Pouring** - wet cement into voids and foundations.
- **Concrete pouring and levelling** – in the wet form.
- **Cutting, scabbling, drilling or demolition** – as dust.

Concrete and mortar cutting produce dust which may also contain silica (see earlier). (Note that concrete and mortar contain crystalline silica.)

Exposure is controlled by eliminating or reducing it where possible and by use of work clothing, gloves, dust masks and eye protection. Removal of contaminated clothing, good hygiene and washing after skin contact are also important.

Wood Dust

Wood is classified in two broad categories – hardwood and softwood. The main activities causing problems arise from sawing, routing, sanding and turning. MDF (medium density fibreboard) is a composite of wood dust and resin and particularly causes asthma.

The smaller the particle size and the greater the amount of dust produced, then the greater the risk of ill-health.

Health problems associated with exposure to wood dust include:

- Skin disorders.
- Obstruction in the nose, and rhinitis; asthma.
- A rare type of nasal cancer.
- Wheezing, coughing and breathlessness.
- Stomach disorders due to ingestion.
- Eyes – soreness, watering, conjunctivitis.

Hardwood and soft wood dusts both have OELs (e.g. 5mg/m3 in the UK) which should not be exceeded. Because some wood dusts are asthmagens, exposure must be reduced to as low as is reasonably practical.

Key controls include:

- Provision of LEV (maintained and inspected) to extract dust at woodworking machines.
- Vacuum-collection rather than sweeping or blowing of wood dust with an airline. Such systems should be suitable and have a HEPA filter (high energy particle arrestor, as for asbestos).
- RPE as well as LEV should be used for particularly dusty tasks.
- Health surveillance may be appropriate for respiratory disorders (asthma in particular).

Health Risks and Controls Associated with Asbestos

Asbestos has been extensively used as a heat-insulating material in lagging of pipes and tanks, and in wall and loft insulation. Asbestos cement has been widely used in panels, particularly for roofing, but also for walls, and in drainage products and pipework. Because of its inertness and lasting properties, asbestos can be found in ceiling tiles, floor tiles and textured finishes. Sprayed asbestos coating on steel members gives improved fire resistance and helps prevent corrosion. Asbestos has also been used in gaskets, packing plugs and asbestos rope.

Three respiratory diseases are associated with asbestos exposure:

- **Asbestosis** - asbestos fibres lodge deep in the lungs and cause scar tissue to form. Extensive scarring leads to breathing difficulties and increases the risk of cancer - can be fatal.
- **Lung cancer** – asbestos fibres in the lung trigger the development of cancerous growths in lung tissue - often fatal.
- **Mesothelioma** - asbestos fibres migrate from the lungs through tissue and into the cavities around the lung, triggering the development of cancerous growths in the lining tissue around the lungs, the heart and the lining of the abdomen.

The effects of asbestos have a long latency period – it will be a long time after exposure has occurred before symptoms are apparent (five to ten years for asbestosis; 20 to 50 years for mesothelioma).

Duty to Manage Asbestos

Identification

Asbestos or asbestos containing materials (ACMs) are not easily recognised, so laboratory testing of samples is often required. It is even more difficult when ACMs are concealed by decorations or coatings, so workers often do not know when and where they may come across asbestos in their work. ACMs may be present if the building was constructed or refurbished before 1985, and asbestos cement was used up until 1999 in the UK. Use may have been more recent in other countries.

The three main types of asbestos that have been used commercially are:

- Crocidolite (blue).
- Amosite (brown).
- Chrysotile (white).

The type of asbestos cannot be identified just by its colour, but requires microscopic examination in a laboratory.

Some products have one type of asbestos in them while others have mixtures of two or more. All types are dangerous, but blue and brown asbestos are known to be more dangerous than white.

Surveys

In order to establish if asbestos is present in a building, a survey can be carried out.

Topic Focus

A **survey** can be:

- **Type 1** – presumptive: to locate materials assumed to contain asbestos and note what condition they are in. No sampling is done. This survey can be carried out by any responsible person.
- **Type 2** – standard sampling: the same as Type 1 but samples are taken and analysed to confirm whether asbestos is present. This is done only by a qualified asbestos specialist.
- **Type 3** – full access sampling: involves getting full access to all parts of the building, using destructive inspection if necessary. This type is usually used just before demolition or major refurbishment and is only done by a qualified asbestos specialist.

The results of all types of survey, including information on the accessibility, condition and surface treatment of any presumed or known ACMs, should be recorded and the information provided to anyone who may work on, or disturb, these materials. Safety representatives are entitled to this information.

If there is doubt as to whether asbestos is present, it should be presumed that it is present and also that it is not restricted to white asbestos, and national or local regulations should apply accordingly.

Where to Look for Asbestos

Some examples of asbestos use include:

- **Insulation board** – contains around 20 – 45% asbestos; used for fire protection, heat and sound insulation; in ducts, in-fill panels, ceiling tiles, wall linings, bath panels and partitions, fire doors.
- **Pipe lagging** – contains 55 – 100% asbestos; thermal insulation on boilers and pipes.
- **Fire blankets** – used in homes and commercial catering kitchens.
- **Floor tiles** – very similar in appearance to ordinary vinyl or plastic tiles.
- **Sprayed coatings/loose fill** - inside roofs, lofts, etc.
- **Rope and gaskets** – around jointed pipe and in joints in boilers as seals.
- **Roof felt** – rolls of felt laid on roofs; roof tiles.
- **Decorative paints and plasters** – lining walls, around and beneath staircases, etc.; "artex" ceiling coatings.

Asbestos cement products include:

- Corrugated roof sheets.
- Rainwater goods (fountain heads, guttering, drain pipes, etc.).
- Cold water tanks and toilet cisterns.

Procedure for Asbestos Discovery During Construction

A procedure must be in place covering the actions to take on discovering asbestos in unknown locations. This will include stopping work and immediately informing the site supervisor. He/she should arrange for the area to be sealed off until a formal survey can be carried out.

Accidental Exposure to Asbestos

Requirements:

- Stop work immediately.
- Prevent anyone entering the area.
- Arrangements should be made to contain the asbestos - seal the area.
- Put up warning signs – "possible asbestos contamination".
- Inform the site supervisor immediately.
- If contaminated, all clothing, equipment, etc. should be decontaminated and disposed of as hazardous waste.
- Undress, shower, wash hair; put on clean clothes.
- Contact a specialist surveyor or asbestos removal contractor.

Requirements for Removal

Provided asbestos is contained and left undisturbed it can be retained and managed with no adverse effects. Experience in many countries has shown that systematic removal measures are very expensive. France and the USA adopted a management and control strategy and concluded that improper removal might cause a problem where no problem existed before.

In the UK the HSE emphasises the fact that in many cases asbestos can be retained and managed. Where it is to be removed, then a number of controls apply covering the licensing of operators; a plan of work; and information, instruction and training.

Licensing

Most asbestos removal work should be undertaken by a contractor licensed by the competent authority and following national or local regulations, but any decision on whether particular work should be licensed is based on the specific risks involved. Work should only be **exempt** from licensing if it meets the following criteria:

- The work is sporadic and of low intensity.
- Risk assessment shows the exposure will not exceed any limits.
- The work involves short, non-continuous maintenance activities.
- The work involves the removal of materials in which asbestos fibres are firmly linked to a matrix (e.g. asbestos cement sheet).
- The work involves encapsulation or sealing of ACMs in good condition.
- The work involves air monitoring and sampling.

Plan of Work

Work with asbestos should not start without a written plan detailing how the work is to be carried out. The plan should be kept at the premises where the work is done for the duration of the work. For final demolition or major refurbishment, the plan will usually require that asbestos is removed before any other major works begin.

The plan should specify what control measures are required for managing the risk, including:

- Monitoring the condition of any asbestos or ACMs.
- Ensuring asbestos or ACMs are maintained or safely removed.
- Providing information about the location and condition of any asbestos or ACMs to anyone liable to disturb it/them.
- Making this information available to the emergency services.

The measures specified in the plan must be implemented and recorded.

The plan is to be reviewed and revised at regular intervals, and immediately if there is reason to suspect that it is no longer valid, or there has been a significant change in the premises to which the plan relates.

Topic Focus

Typical control measures for removing asbestos:

- Restrict access to the area.
- Enclose the work area and keep it under negative pressure, testing the sealed area for leaks.
- Provide appropriate PPE (coveralls, respirators, etc.) and a decontamination unit.
- Ensure removal operatives are suitable trained.
- Use controlled wet removal methods (e.g. water injection, damping down the surface to be worked on). Dry removal processes are unacceptable.
- Use a wrap-and-cut method or glove bag technique (a method of removing asbestos from pipes, ducts, valves, joints and other non-planar surfaces).
- Where appropriate, use measures which control the fibres at source, e.g. by using vacuuming equipment directly attached to tools. Failing this, use equipment hand-held by a second employee right next to the source emitting the fibres (known as 'shadow vacuuming').
- Thoroughly clean the area and ensure the air is clear of asbestos (testing is likely to be needed) upon completion of the work.

Worker exposure should always remain below national or local limit values. Single limit values for all types of asbestos vary from country to country, and are measured in different ways. Recent examples include:

- UK – all types: 0.1 fibres per cm^3 (four hours continuous exposure).
- Australia – 1.0f/ml (fibres per millilitre of air).
- Canada – amosite 0.5f/ml; chrysotile 1.0f/ml; crocidolite 0.2f/ml.
- France – all types: 2.0f/ml.

- Germany – all types: 1.0f/ml.
- India – amosite and chrysotile 2.0f/ml; crocidolite 0.2f/ml.
- Indonesia – amosite and chrysotile 1.0f/ml; crocidolite 4.0f/m.
- Nigeria – all types: 2.0f/ml.
- Spain – all types: 2.0f/ml.

In addition, short-term exposures must also be strictly controlled and work methods that control the release of fibres should be used.

As well as reducing exposure to asbestos to the absolute minimum, control measures should be put in place to protect those working with asbestos, e.g. RPE, PPE, laundering procedures, air monitoring and medical surveillance.

Respiratory Protective Equipment

Suitable RPE should always be provided where exposure can be above the control limits.

The RPE provided must comply with national or local standards (e.g. in the EU be marked with a CE symbol) and matched to:

- The exposure concentrations (expected or measured).
- The job.
- The wearer.
- Factors related to the working environment.

RPE should be examined and tested at suitable intervals by a competent person, and a suitable record kept for five years. Respirator testing involves daily checks, monthly checks, and full performance checks every six months. Operator checks would involve fit testing to see that the correct size and model are used to provide an adequate face seal.

Protective Clothing

- **Overalls**

  Only wear **disposable** (hooded) overalls – cotton not recommended.

  Wear waterproof overalls for outdoor work.

  A few tips include:

  – Wear one size too big to avoid splitting the seams.
  – If the cuffs are loose, seal with tape.
  – Avoid long-sleeved shirts - they are difficult to cover properly.
  – Wear the overall legs over footwear – tucking them in lets dust into footwear.
  – Wear the hood over the RPE straps.
  – Dispose of used overalls as asbestos waste.

  Caution – never take used overalls home.

- **Gloves**

  – If worn, use single-use disposable gloves.
  – If latex, choose "low-protein powder" gloves.
  – Dispose of as asbestos waste.

- **Footwear**

  Boots are preferable to disposable overshoes which may cause risk of slipping.

  Caution – never use laced boots - they have lace holes to catch asbestos fibres and are difficult to clean.

Information, Instruction and Training

Anyone removing asbestos must have training that includes:

- Properties of asbestos, its effects on health, including its interaction with smoking.
- The types of products or materials likely to contain asbestos.
- The operations which could result in asbestos exposure.
- Safe work practices, preventive control measures, and protective equipment.
- The purpose, choice, limitations, proper use and maintenance of RPE.
- Emergency procedures.
- Hygiene requirements.
- Decontamination procedures.
- Waste handling procedures.
- Medical examination requirements.
- The control limit and the need for air monitoring.

Employees should be made aware of the significant findings of the risk assessment, and the results of any air monitoring carried out, with an explanation of the findings.

Air Monitoring

Sampling for asbestos in the air should be carried out by trained staff, in three situations:

- **Compliance sampling** – within control or action limits.
- **Background sampling** – before starting work (i.e. removal).
- **Clearance sampling** – after removal and cleaning the area.

Medical Surveillance

Surveillance for persons who are exposed to asbestos requires:

- A health record is kept (for 40 years in the UK) and maintained.
- Medical surveillance by a doctor where exposure exceeds the action level. A certificate of medical examination for asbestos should be kept for four years.

Requirements for Disposal

Asbestos waste is classified as a controlled waste under national or local regulations and, dependent upon its source and properties, may also be classified as hazardous waste under the same regulations. Under these regulations, movements of hazardous waste should be carried out by a licensed carrier and may have to be tracked by means of a consignment note system until the waste reaches a suitable licensed waste management facility.

The Basel Convention against cross-boundary transport of wastes, for instance, lists wastes that contain asbestos in the catalogue of substances that have to be controlled.

- Double wrap and label the waste – standard practice is to use a red (UN) inner bag, and a clear outer bag with carriage of dangerous goods (CDG) warnings and asbestos code visible.
- The waste should be carried in a sealed skip or vehicle with a segregated compartment for asbestos, easily cleanable and lockable.
- It must be transported by a registered waste carrier and taken to a licensed disposal site. The waste consignment note should be kept for three years.

More...

You may like to access:

http://www.hse.gov.uk/asbestos/essentials/index.htm

to source more information on working with asbestos.

Revision Questions

22. Identify six chemical and four biological agents commonly encountered in construction activities.
23. Identify two asphyxiant gases and outline their ill-health effects
24. Identify three sources of organic solvents used in construction, and describe their ill-health effects.
25. Identify the controls used to avoid or reduce exposure to cement dust and wet cement.
26. Identify the three main types of asbestos.
27. What steps are to be taken if you discover asbestos on site?
28. What are the three air-monitoring sampling methods, and when should they be carried out?

(Suggested Answers are at the end of Unit ICC1.)

Safe Handling and Storage of Waste

Key Information

- Waste must be handled and stored safely prior to disposal.
- Employers must fulfil their duty of care to manage hazardous and non-hazardous waste according to national or local legal standards. This includes keeping different types of waste separate to avoid mixing and contamination.

Jargon Buster

Waste

Something that is discarded, or is going to be discarded.

Duty of Care

A duty of care is applicable to all persons involved in the generation, importation, handling, transporting and disposal of controlled waste. It places a responsibility on all such people to ensure that waste:

- Is managed legally.
- Does not escape from control.
- Is transferred only to an authorised person.
- Is adequately described.
- Is accompanied by appropriate documentation, i.e. a Transfer Note.

Contamination of a fresh water drainage system with waste oil

Classification of Waste

Waste can be classified in the following way:

- **Controlled Waste**

  Controlled waste is any domestic, commercial or industrial waste or any substance which is scrap, effluent or unwanted surplus from a process. Certain types of waste such as agricultural and radioactive waste are excluded from this definition of controlled waste.

- **Hazardous Waste**

  Hazardous waste is generally waste that is highly flammable, toxic, carcinogenic, corrosive, etc. However, many products such as batteries, refrigerators, freezers, televisions, fluorescent light tubes and computer monitors which may cause longer-term problems are also hazardous waste.

Non-hazardous waste generally includes household waste, paper, wood and other biodegradable materials.

There are usually regulatory bans on the mixing of different categories of hazardous wastes, or the mixing of hazardous with non-hazardous waste, unless this is authorised by national or local regulation by licence.

Regulations may require that:

- Hazardous waste producers **identify** when their waste is hazardous.
- Premises that produce or hold hazardous waste over certain amounts (e.g. >500 Kg per annum) may need to be registered with their competent authority.
- A **Consignment Note** should be completed when any hazardous waste is moved from premises.

Worker loading a waste compactor. Note the compactor is for cardboard only. Also note the access platform to give safe access to the edge of the skip

Safe Handling and Storage

Leaving detailed environmental legislation issues aside, it is important to consider the health and safety issues associated with the management of waste in a workplace.

Factors to consider include:

- The **hazardous** nature of the waste – the waste may be inherently hazardous to staff involved in handling it, e.g. toxic or radioactive. This may require use of PPE.
- The waste may present a **manual handling** risk. This might be overcome by the use of mechanical handling equipment or handling aids.
- Storage equipment such as skips, bins and compactors may be **difficult to access** and may require steps or platforms to allow safe use.
- Compactors will have **moving parts** that must be effectively guarded to prevent access.
- Collection **vehicles** such as skip lorries present a significant hazard when manoeuvring, especially when reversing, and a banksman should be used.
- The waste may present a temptation to scavengers (e.g. waste metals) and to vandals (unlocked storage tank valves) and so must be **secured**.
- Any escape may have the potential to cause pollution. Adequately securing the waste might control this risk, but emergency spill or release plans may also be required, along with the necessary personnel, equipment and training to put these plans into effect.
- Waste types (streams) must be **segregated** to prevent the mixing and contamination of one type of waste with another. This usually requires separate secure storage for each type of waste and the clear identification of types.
- Appropriate **documentation** should accompany the waste and the duty of care, to dispose of waste in line with legal requirements, must be fulfilled.

Revision Questions

29. A duty of care is placed on persons who generate, import, handle, transport and dispose of controlled waste. What responsibilities does the duty of care place on such persons?
30. Name six hazards that might arise when handling and storing waste for disposal.
31. What controls are placed on the disposal of hazardous waste?

(Suggested Answers are at the end of Unit ICC1.)

Summary

This element has dealt with some of the hazards and controls relevant to chemical and biological health hazards in the construction environment.

In particular this element has:

- Outlined the different forms of chemicals (liquids, gases, vapours, mists, fumes and dusts) and biological agents (fungi, bacteria and viruses).
- Identified the classification of chemicals (toxic, harmful, corrosive, irritant and carcinogenic) and the meaning of the terms "acute" and "chronic" when used to describe their effects.
- Identified the main routes of entry into the body (inhalation, ingestion, absorption through the skin and injection through the skin) and some of the body's defence mechanisms.
- Explained the factors to be considered when undertaking an assessment of the health risks from substances encountered in construction workplaces.
- Outlined the sources of information available about the substances, and the use of data sheets and product labels.
- Described some of the equipment that is used when undertaking basic surveys to assess concentrations of substances in the workplace (e.g. stain tube detectors).
- Explained the purpose and principles of occupational exposure limits and their relevance in short-term and long-term exposures.
- Outlined the control measures that should be used to reduce the risk of ill-health from exposure to hazardous substances
- Described the Principles of Good Practice as regards to controlling exposure to hazardous substances: minimising emissions; taking into account routes of exposure; exposure control to be proportional to risk; choosing effective controls; using PPE; regular checks and reviews of controls in place; provision of information and training. Control measures should not increase the overall risks.
- Described common measures to implement the Principles of Good Practice: eliminate or substitute; change the process; reduce exposure time; enclose or segregate; LEV; dilution ventilation; RPE and PPE; personal hygiene; and health surveillance.
- Outlined the hazards, risks and controls associated with specific hazardous agents.
- Described the generation and control of dusts on a construction site, in particular cement and wood dusts.
- Described the health risks and controls associated with asbestos and the duty to manage asbestos.
- Outlined the basic requirements related to the safe handling and storage of waste on construction sites.