UNITS EC1 AND EC2

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RRC INTERNATIONAL

# NEBOSH CERTIFICATE IN ENVIRONMENTAL MANAGEMENT

## UNIT EC1: MANAGEMENT AND CONTROL OF ENVIRONMENTAL HAZARDS

## UNIT EC2: ENVIRONMENTAL PRACTICAL APPLICATION

Autumn 2015

RRC Module No:  EC1.1

Autumn 2015 edition

# NEBOSH ENVIRONMENTAL CERTIFICATE

## UNIT EC1: MANAGEMENT AND CONTROL OF ENVIRONMENTAL HAZARDS

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RRC Module No: EC1.1

ISBN for this volume: 978-1-911002-51-2 Second edition Autumn 2015

## ACKNOWLEDGMENTS

RRC International would like to thank the National Examination Board in Occupational Safety and Health (NEBOSH) for their co-operation in allowing us to reproduce extracts from their syllabus guides.

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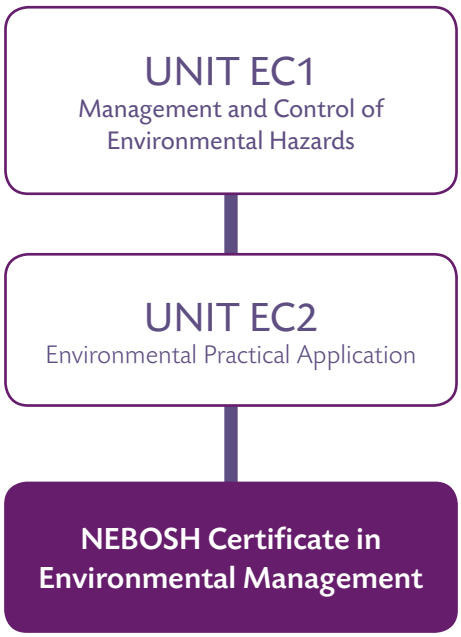
## COURSE STRUCTURE

This textbook has been designed to provide the reader with the core knowledge needed to successfully complete the NEBOSH Certificate in Environmental Management. It follows the structure and content of the NEBOSH syllabus.

The NEBOSH Environmental Certificate consists of two units of study. When you successfully complete any of the units you will receive a Unit Certificate, but to achieve a complete NEBOSH Environmental Certificate qualification you need to pass both units within a five-year period. For more detailed information about how the syllabus is structured, visit the NEBOSH website (www.nebosh.org.uk).

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# User Guide

Before you start to use this textbook, take a moment to read this User Guide.

At the start of each element you will find a Contents table and a list of Learning Outcomes. These are important because they give you an idea of the different topics you will be studying and what you are aiming to achieve.

## KEY INFORMATION

Each main section of material starts with a Key Information box. This box presents an overview of the important facts, ideas and principles dealt with under the section heading. There is no depth or detail here, just the basics.

After the Key Information box comes the main content. The main content has been designed to explain and describe the topics specified in the relevant section of the syllabus to the expected level. Examples have been given to illustrate various ideas and principles in a variety of different workplaces.

## TOPIC FOCUS

Topic Focus boxes provide depth and detail by concentrating on a very specific topic area.

## GLOSSARY

Glossary boxes contain descriptions or definitions of words or phrases that are included in the main content.

## HINTS AND TIPS

Hints and Tips boxes contain simple ideas that can help you as you work through the materials and prepare for the end-of-course exam.

## MORE...

More... boxes contain sources of further information. (Websites are current at the time of writing.) Although this book includes everything you need, it is worth looking at these additional sources if you can. This will give you a broader and deeper understanding.

## REVISION QUESTIONS

At the end of each section you will find Revision Questions. These are not past exam questions, but should be useful for self-assessment.

You can mark your answers against the Suggested Answers provided.

## SUMMARY

Each element finishes with a Summary. This presents a very concise reflection of the key ideas and principles contained in the element. When you have finished studying an element you might use the summary to test your recall of the detailed information contained within the element.

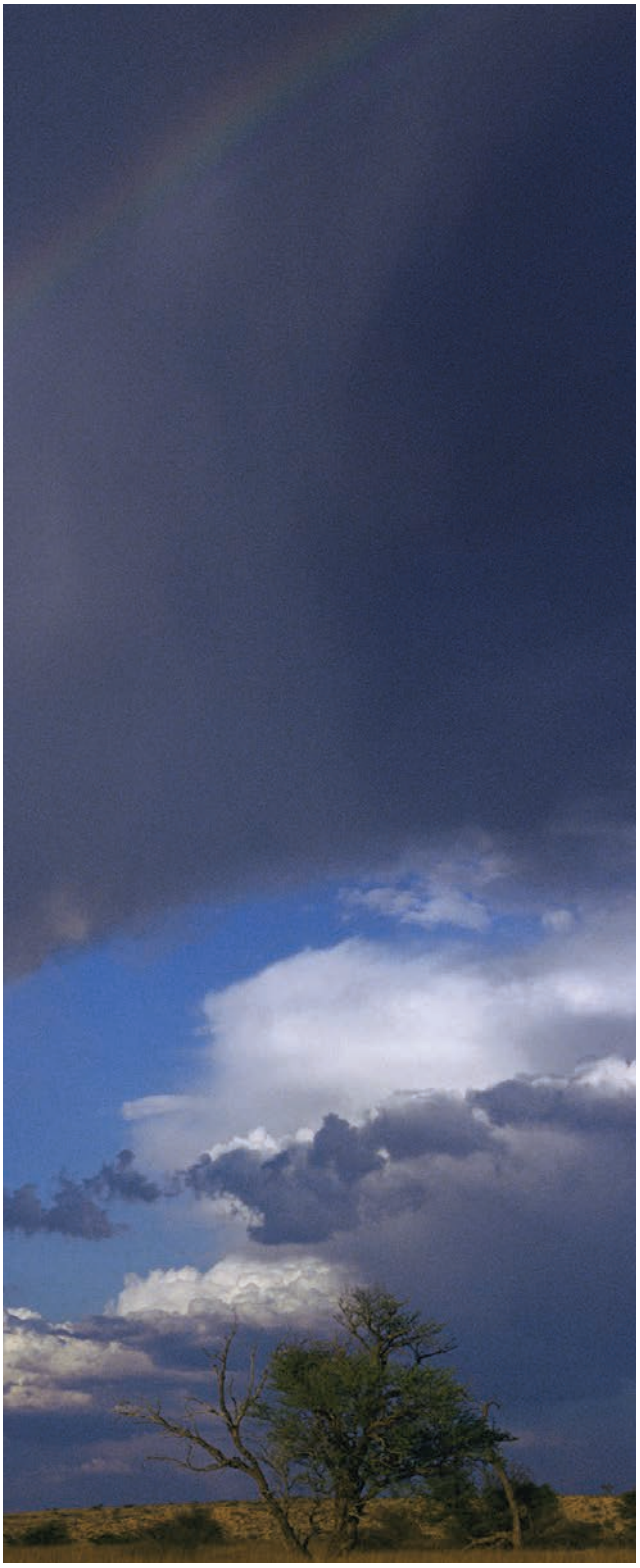
When you have studied all of the elements in a unit you should move on to look at the Revision and Examination Guide.

## EXAM SKILLS


After each element you will find a short Exam Skills section containing an exam-style question (or two) for you to practise answering. Guidance on how to answer is provided, together with a Suggested Answer for you to compare with your own.

# FOUNDATIONS IN ENVIRONMENTAL MANAGEMENT

ELEMENT 1



## LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Outline the scope and nature of environmental management.
2. Explain the ethical, legal and financial reasons for maintaining and promoting environmental management.
3. Outline the importance of sustainability and its relationship with Corporate Social Responsibility.
4. Outline the legal framework for the regulation of environmental management.
5. Explain the role of national governments and international bodies in formulating a framework for the regulation of environmental management.

# Contents

## KEY INFORMATION

- Understanding and managing the environment requires knowledge of many topics, including geography, geology, hydrogeology, planning, public health, sociology, pollution and pollution controls.
- Barriers to good environmental management are:
  - The complex nature of the environment.
  - Conflicting demands in an organisation.
  - Difficulties in changing people's behaviour.
- Environmental impacts can be local, national or regional; and international or global.
- Some key environmental issues include:
  - Local pollution from noise, waste, lighting and odour.
  - Carbon emissions and climate change.
  - Air pollution causing poor air quality.
  - Release of pollutants causing the protective ozone layer in the stratosphere to become depleted.
  - Land grabbing.
  - Use of fossil fuels.
  - Inappropriate disposal of waste.
  - Impacts occurring from poor agricultural practices.

## DEFINITION OF THE ENVIRONMENT

The "environment" is everything that surrounds us. This encompasses:

- the physical resources of the Earth, including the atmosphere, water, the land and raw materials;
- the living resources of animal and plant life; and
- human populations

Environmental management is concerned with understanding these elements and how they interrelate. The international environmental management system standard **ISO 14001**:2004 defines the environment accordingly as:

> *"Surroundings in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans and their interrelation.*
>
> *NOTE: Surroundings in this context extend from within an organisation to the global system."*
>
> (Source: ISO 14001:2004)

## GLOSSARY

### NATURAL RESOURCES

Land or raw materials that occur naturally in the environment.

### FLORA

Plant life.

### FAUNA

Animal life.

### ENVIRONMENTAL MEDIA

Air, land and water.

## THE MULTI-DISCIPLINARY NATURE OF ENVIRONMENTAL MANAGEMENT

Environmental management clearly has a very broad scope. One of the fascinations of studying the environment is the breadth of topics and disciplines that are involved. Environmental management typically involves concepts from scientific and technical disciplines, e.g. physics, chemistry, biology, geology and engineering, but it also has social and political dimensions, e.g. town and country planning, public health and legislation.

In studying an environmental course such as this you will be given a general, but not specialist, understanding of a wide variety of topics included in these disciplines.

### GLOSSARY

**GEOLOGY**

Study of the physical materials that make up the Earth.

**HYDROGEOLOGY**

Study of the movement of groundwater in the soil and rocks.

**SOCIOLOGY**

Study of human social activity.

## Barriers to Good Standards of Environmental Management

Many organisations of all types and sizes successfully manage their environmental impacts. But we need to recognise at the outset that the broad scope of environmental management poses a number of barriers to good environmental management – for example:

- **Complexity**
  Organisations are complex, with numerous environmental impacts, such as waste generation and disposal, energy use, emissions to air, or discharges to water. Deciding which impacts to address and how to achieve improvements requires background knowledge of environmental impacts, how they interact, and options for improvement. An understanding of how changes of process or procedure can affect the business is also important.
- **Competing and Conflicting Demands**
  Organisations need to operate in an efficient and effective manner to deliver the right product or service to their customers, on time, and at a competitive price. Commercial companies need to make a profit in order to survive. Individual people in an organisation may be driven by financial, rather than environmental, pressures. All organisations need to comply with applicable legislation. There is often conflict between environment and health and safety. For example, to protect workers from high dust levels in the workplace, dust is ventilated to the atmosphere. If not controlled, this may cause an environmental problem, with plants being covered in dust, or a nuisance being caused to nearby residents.
- **Behavioural Issues**
  Changing the way people behave in any given situation is one of the most difficult things to achieve. In recent years, the cost of fuel and generally running a car has increased significantly, yet people are still unwilling to give up car ownership and use. This is in spite of significant publicity regarding the negative environmental impact of car use, from contributing to climate change to decreasing local air-quality standards. This is no different from attitudes in the workplace; if we are to be successful in changing behaviour patterns, we must be prepared for it to take time and we must provide people with good reasons to change.

### MORE...

The *United Nations Environment Programme (UNEP) Year Book* is an annual publication that provides updates on environmental policy and science and identifies significant emerging environmental issues. It is available at:

www.unep.org/yearbook/2014

## SIZE OF THE ENVIRONMENTAL PROBLEM

We have seen that the environment covers a wide range of issues and disciplines. When we think about our own organisations we need to recognise that we can contribute to local, regional and global environmental issues. The following figure illustrates this.


Relationship between local, national and international environmental issues

The various sections of this course cover the main environmental issues in some depth, but let's begin by taking an overview of some of the key local, regional and global environmental concerns that society is dealing with today.

## Local Effects of Pollution

These can include:

- Poor air quality due to the pollution caused by high levels of vehicle traffic or local industrial processes.
- Contaminated land from industrial processes where spills or accidents have occurred, leaving ground contaminated with pollutants such as heavy metals (cadmium, lead, etc.).
- Water pollution from accidental spillages from industry and road traffic accidents, or deliberate pollution of rivers.

## Noise, Odour and Light

Pollution by noise, odour and light is becoming an increasing problem and all of these types of pollution are often controlled through legislation.

Operating conditions may also be imposed on businesses located in sensitive areas:

- under planning law; or
- through industrial environmental permits.

## Waste

Waste is often heavily regulated, for example under the **Waste Framework Directive (2008/98/EC)** in the European Union. This is because unregulated and uncontrolled disposal of waste can lead to the spread of disease through:

- contact with the waste itself; or
- an increase in numbers of vermin species, such as rats, which aid the spread of disease.

Waste can also contaminate land and water.

Uncontrolled disposal of waste

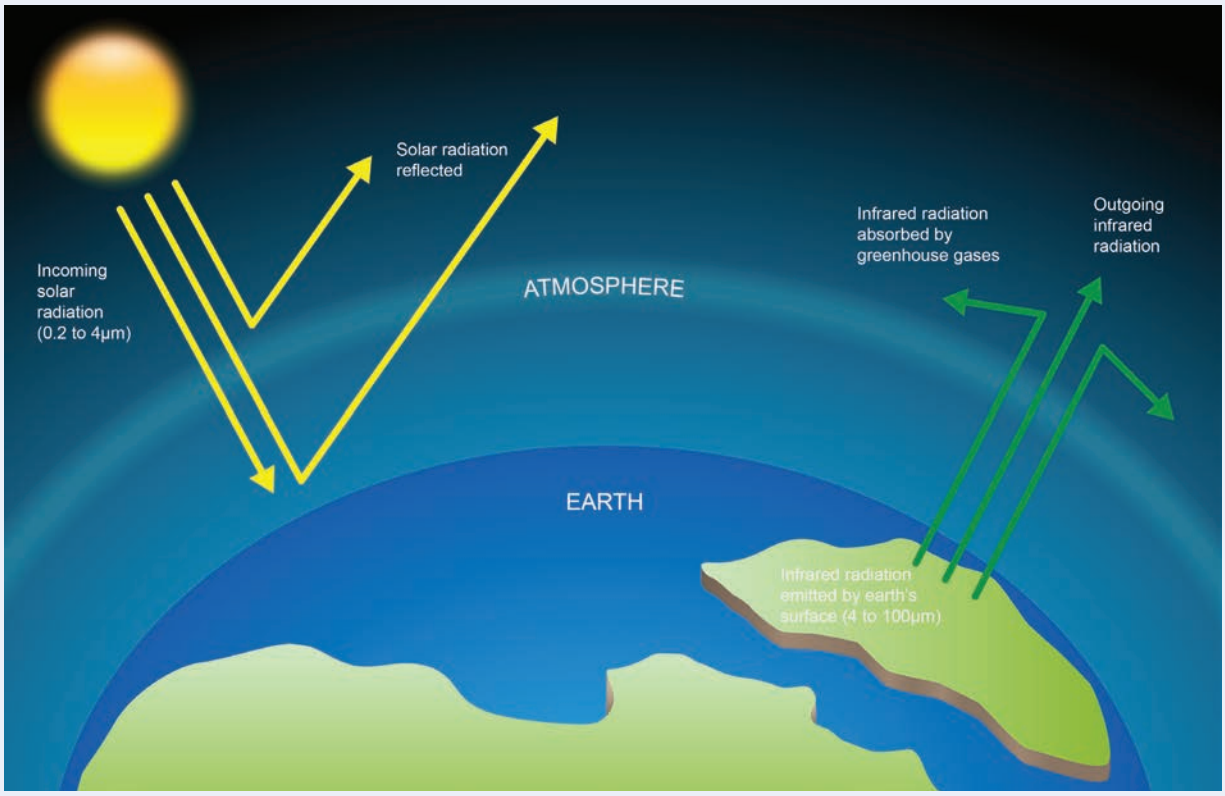
## TOPIC FOCUS

### Global Warming

The first decade of the 21st century was the warmest on record and measurements over the last 150 years show that the temperature of the atmosphere has increased by around one degree Celsius. This phenomenon is commonly known as global warming.

There is now strong evidence that global warming is related to pollution of the atmosphere, through the mechanism known as the greenhouse effect.

What is the greenhouse effect? It is actually a natural phenomenon. The sun irradiates the Earth with energy and as the Earth warms, it emits energy back into space as infrared radiation. Some of this radiation is absorbed by greenhouse gases that occur naturally in the atmosphere (primarily water vapour, carbon dioxide and methane); the effect of this is to reduce heat loss from the Earth. Were it not for the greenhouse effect the temperature of the Earth would be well below zero degrees Celsius.



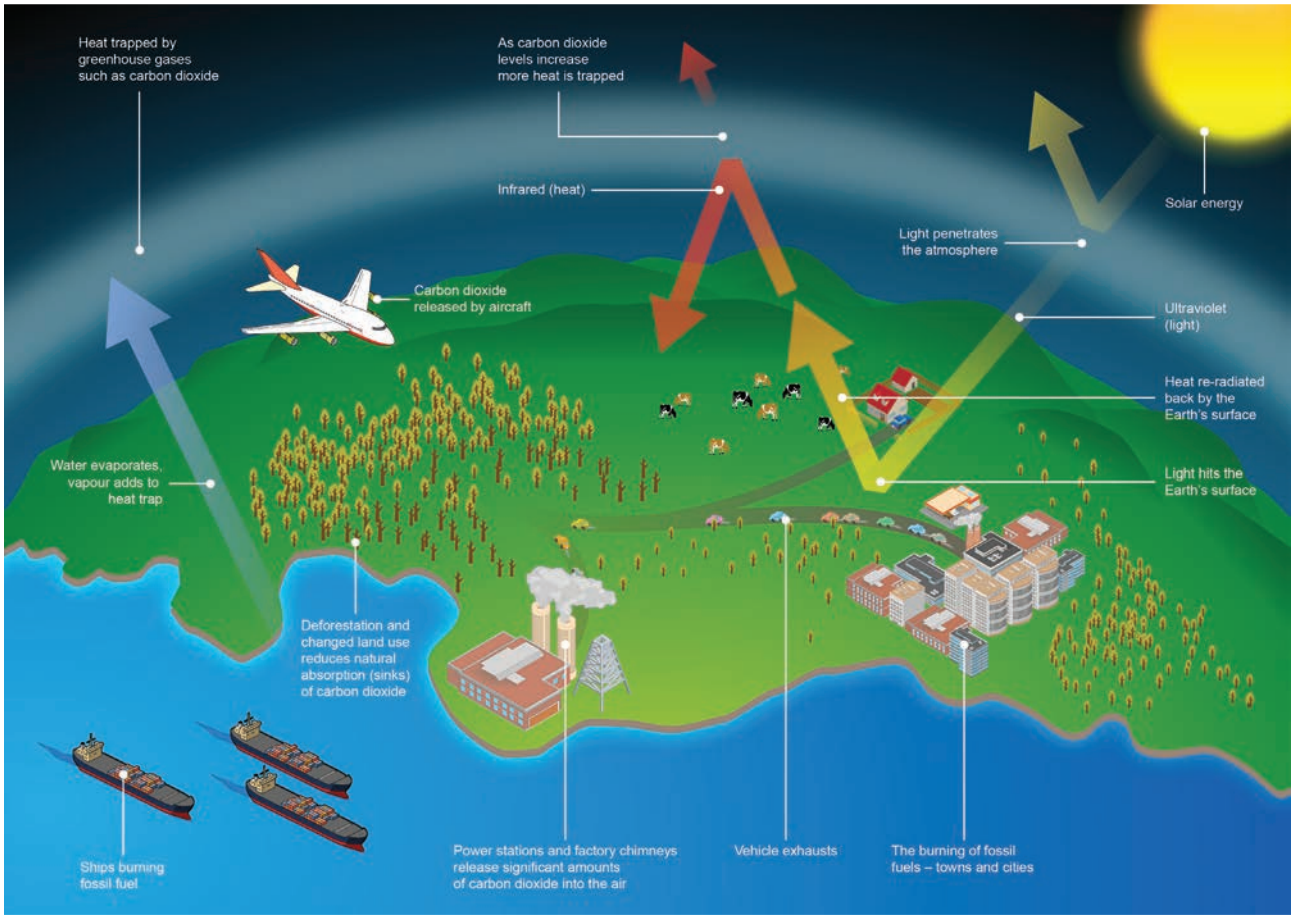

The greenhouse effect

The problem is that burning fossil fuels (e.g. coal, oil, gas, petrol, diesel), which account for more than 85% of the world's energy consumption releases large quantities of carbon dioxide into the atmosphere. Levels of carbon dioxide in the atmosphere have consequently increased significantly during the past 50 years.

Enhanced levels of carbon dioxide in the atmosphere are now believed to be artificially increasing the greenhouse effect, leading to global warming.

What is so alarming about a warmer planet?

- Sea levels will rise – primarily through the melting of the polar ice caps. This could result in widespread coastal flooding.
- Climate change – global warming is likely to trigger changes in the Earth's climate. This could potentially have very serious consequences. For example, major food-producing areas might begin to suffer droughts, reducing our ability to feed ourselves. There are also likely to be more extreme and disruptive weather events, such as high winds and floods.




The main man-made sources of $CO_2$ emissions and the greenhouse effect
(reproduced courtesy of Scottish Power)

To reduce fossil-fuel burning (mainly power stations and road vehicles) we must:

- **Reduce energy consumption**, e.g. improved insulation, double-glazing, attention to heating and ventilation, turning lights off.
- **Increase efficiency of energy use**, e.g. best practice in the operation of plant and processes, use of fuel-efficient vehicles (diesels give about 30% better performance than petrol-driven vehicles).
- **Use alternative energy sources**: e.g. wind, water, or nuclear energy.
- **Burn fuels which release less $CO_2$**: natural gas (methane) produces more than twice as much energy (per kg), and $CO_2$ makes up only 75% of the combustion products compared with coal.

## MORE...

Further information on the science behind climate change can be found in the *Intergovernmental Panel on Climate Change* (IPCC) Fourth Assessment Report Climate Change 2007:
The Physical Science Basis, available at:

www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html

## Air Pollution and Ground-Level Ozone

The main causes of air pollutants are vehicle exhaust emissions and industrial activities. Vehicles emit a mixture of gases and particulate material that can cause harm to the environment and damage human health. Oxides of sulphur and nitrogen (often referred to as $SO_x$ and $NO_x$) can react with atmospheric gases, in the presence of sunlight, to produce harmful low-level ozone. While we need ozone in the troposphere part of the atmosphere, at low altitudes where people live it is a poisonous gas. These same $SO_x$ and $NO_x$ gases can also combine with moisture in the atmosphere to produce dilute sulphuric or nitric acid (falling as so-called "acid rain"), which causes damage to buildings, especially many older buildings that are made from materials such as marble and limestone.

## Air Pollution and the Ozone Layer

Life on Earth is protected from the damaging effects of ultraviolet radiation by a layer of ozone molecules ($O_3$) in the lower stratosphere, between 15 and 25km above the Earth's surface. Ozone absorbs ultraviolet radiation, one of the major causes of skin cancers. Certain chemicals (ozone depleters) can destroy the ozone layer.

It is believed that the ozone layer is depleting at a rate of 5% every ten years over northern Europe, with depletion extending south over the Mediterranean and southern USA. However, ozone depletion is most dramatic over the polar regions, due to particular upper atmospheric conditions, and a continent-sized hole has developed over Antarctica.

Most ozone depleters are chemically-stable compounds containing the halogen elements chlorine or bromine. These compounds have typically been used as refrigerant gases, as propellants for aerosol sprays, as foam-blowing agents, as solvents and in fire-fighting systems (e.g. CFCs, HCFCs, carbon tetrachloride, trichloroethane, halons).

These ozone-depleting compounds are very stable and if they are released by human activities they can persist unchanged in the atmosphere until they drift upwards to reach the ozone layer in the stratosphere. At this altitude, the compounds are exposed to higher levels of UV radiation, which liberates charged chlorine and bromine atoms from the parent molecules. These charged atoms are known as 'free radicals' and are highly reactive. Chlorine and bromine free radicals are able to react with, and break down, ozone molecules in a variety of ways – for example:

A chlorine free-radical reacts with ozone to produce chlorine monoxide and molecular oxygen:

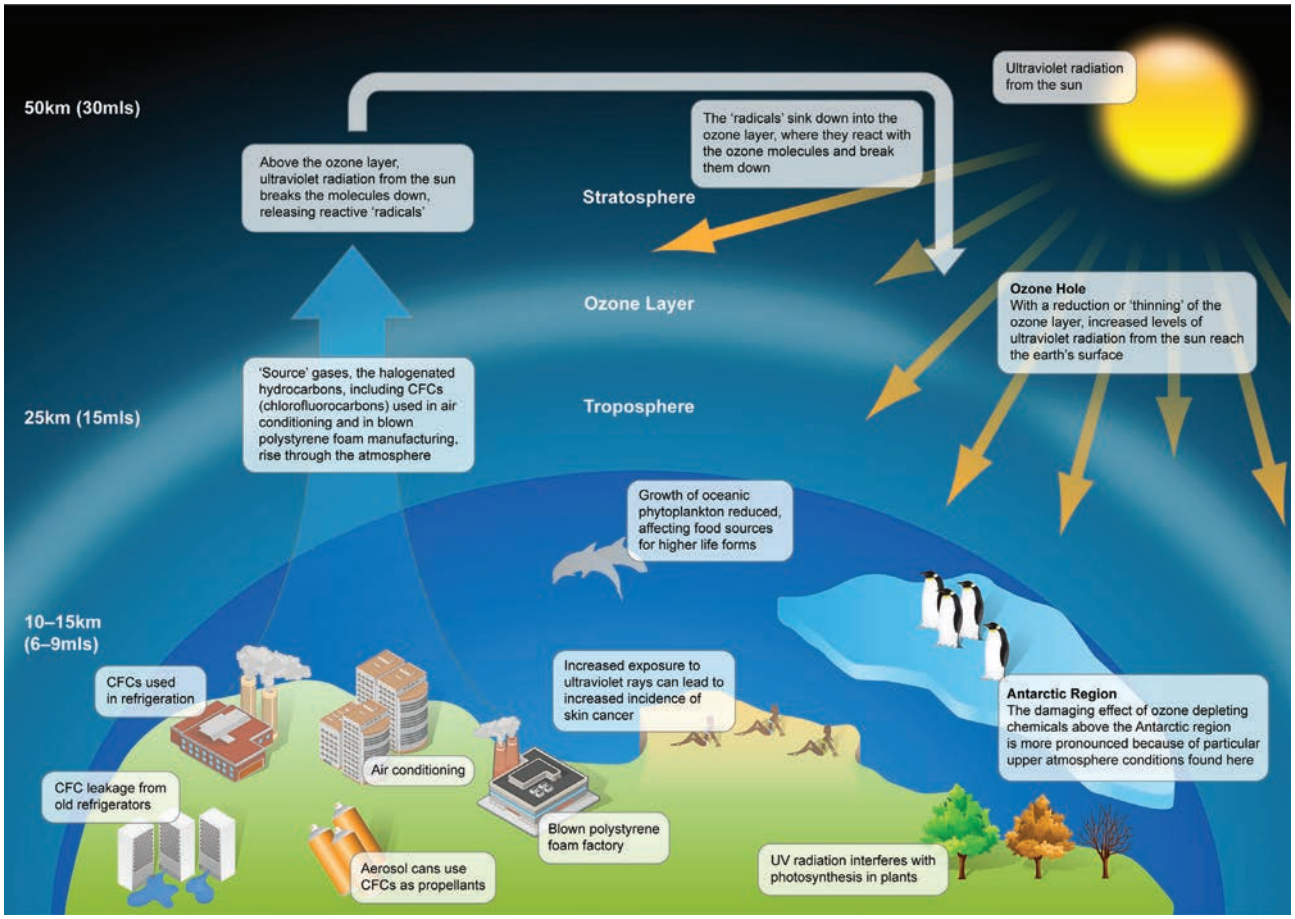
$$Cl + O_3 \rightarrow ClO + O_2$$

The chlorine monoxide so formed may then react to break down more ozone:

$$ClO + O_3 \rightarrow Cl + 2O_2$$

International agreements (especially the Montreal Protocol) are in place to curb the production and use of ozone depleters.

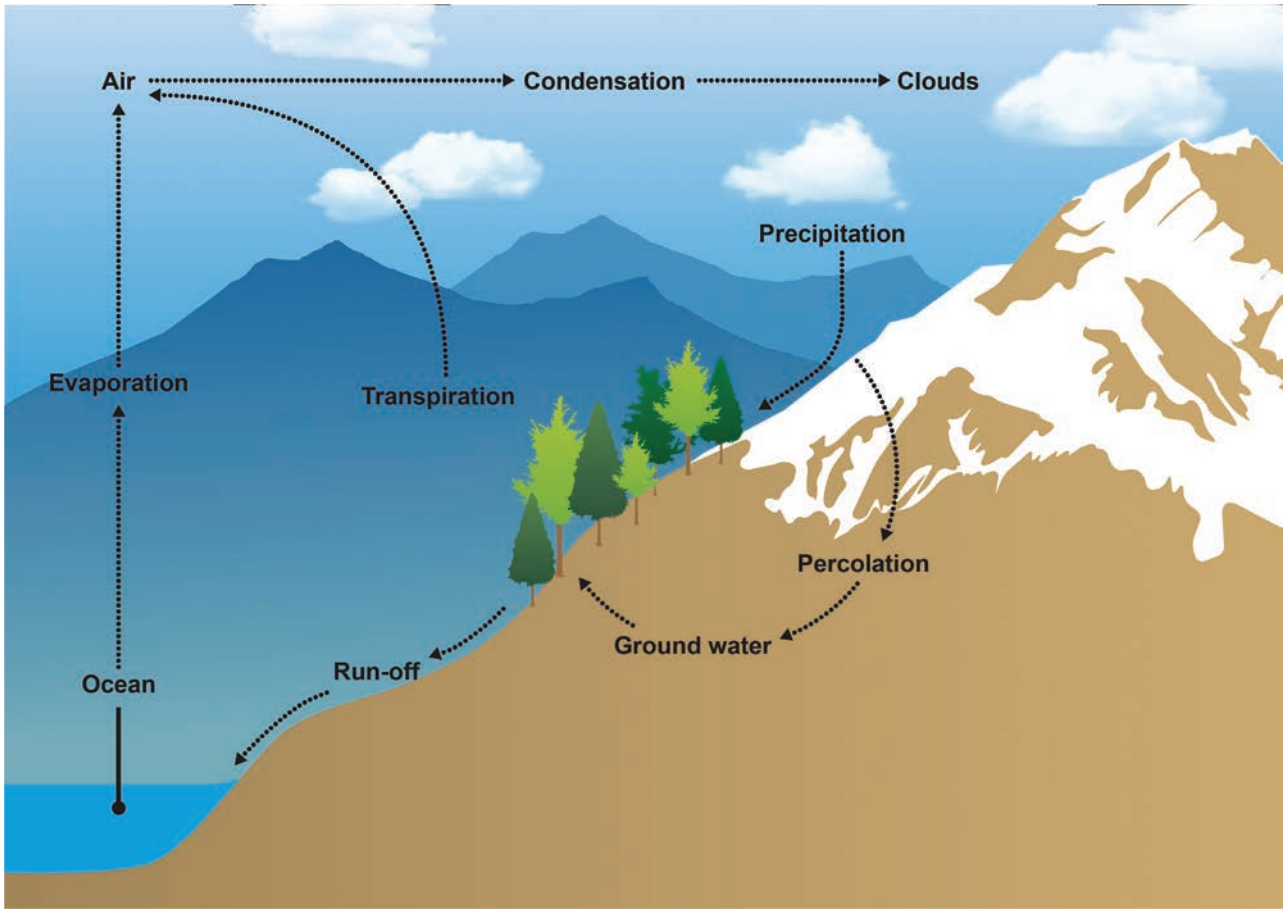
Unfortunately, even if all ozone-depleters were banned today, the chlorine molecules already in the atmosphere would continue to affect stratospheric ozone levels for at least a century.




Depletion of the ozone layer

## Water Resources

Water is an essential resource and is recycled naturally in the environment through the **hydrological cycle**, as shown in the figure on the next page. The demand for water is increasing due to the increase in population and in the amount of water used by individuals; this is especially the case in developed countries, where water is seen as a plentiful and cheap resource.




Natural hydrological cycle

Because of this cycle, there can be an accumulation of pollutants through water catchments, making prevention of pollution particularly important.

## GLOSSARY

### WATER CATCHMENTS

Areas of land that drain water from rain, snow, etc., into a single water body, such as a river and its tributaries.

Water can be polluted:

- Directly, by discharges to rivers and lakes (point sources).
- Indirectly, through:
  - Run-off from land, particularly contaminated land.
  - Deposition of airborne pollutants (non-point sources) into watercourses.

Water quality can be adversely affected by a number of types of pollutants, such as:

- **Nutrients** - excessive levels of nutrients, e.g. nitrogen and phosphorous, can cause excessive growth of aquatic plants. These, in turn, allow certain species, e.g. green and blue-green algae, to dominate a watercourse, especially in slow-moving sections of rivers, or in lakes. This excessive growth eventually prevents the penetration of sunlight and deoxygenates the water at night, adversely affecting other plant and animal life. As the source of pollution is usually run-off from a wide area of agricultural land, it is very difficult to control. This process is known as **eutrophication**.
- **Organic wastes** - human and animal effluent, silage and products such as milk are broken down by aerobic (oxygen-using) bacteria. These wastes promote the growth of aerobic bacteria and, because they have a high oxygen demand, they reduce the level of oxygen in the water that is available to higher life forms, such as fish. These pollutants are said to have a high **Biological Oxygen Demand (BOD)**.
- **Immiscible liquids** - these are liquids that do not mix with water, such as oil-based products. They often form a layer on the top surface of the water and prevent the transfer of oxygen and other gases between the water and the atmosphere. They often also coat the leaves of plants and are toxic to animals.

- **Sedimentation** - suspended solids are a very common type of pollutant and can be caused by many processes, both natural and man-made. A natural process could be run-off from a hillside, while a man-made cause could be dewatering a quarry, or washing down a sand and gravel processing yard.
  - penetration of sunlight into the water and therefore reduces the ability of aquatic plants to photosynthesise, thereby reducing oxygen levels in the water.
  - physical problems such as damaging plants and destroying breeding grounds for aquatic animals.
- **Flow-rate changes** - plants and smaller aquatic animal life are adapted to specific conditions, including flow rate. Any significant changes to these conditions can result in the reduction or changing of the plant and animal species able to survive in that environment.
- **Pathogens** - disease-causing organisms such as bacteria, viruses and parasitic worms can enter the water in untreated sewage and animal wastes.
- **Temperature changes** - warm water can hold less oxygen than cold water. Discharging warm water into cold water, often from an industrial process, can cause oxygen levels to drop and so have an adverse impact on the potential for aquatic plants and animals to thrive in that environment. This problem is worse in slow-moving waters, as the oxygen levels become further depreciated over time and are not replenished by fresh inflowing water.
- **Harmful chemicals** - such as methyl mercury, lead, and salts may be harmful to aquatic plant and animal life. Some of these may be taken up into the food chain and become harmful to humans.
- **Acidity** - pH values of acid rain as low as 2.1 have been measured - the equivalent of raining vinegar! The rain ends up in watercourses. Adverse effects of acidity include:
  - Fish dying in Scandinavian lakes.
  - Distorted, diseased and dying trees in European forests.
  - Damage to buildings, metals, rubber, plastic and nylon.
  - Aluminium and heavy metals such as lead, tin, copper and manganese present in soils being leached out. Metals are toxic to plant and animal species.

As we will cover in more detail later, a framework for the protection of inland, surface water, groundwater, transitional water and coastal water has been developed in the European Union under **Directive 2000/60/EC**, establishing a basis for community action in the field of water policy.

## GLOSSARY

### EUTROPHICATION

Excessive plant growth in water caused by the addition of nutrients and resulting in a depletion of oxygen and water quality in the watercourse.

### ORGANIC

Class of chemical compounds based on carbon - usually includes materials of, or derived from, animals and plants.

### BIOLOGICAL OXYGEN DEMAND

A laboratory procedure for determining the amount of oxygen needed by organisms to break down organic materials in water.

### PHOTOSYNTHESIS

The process that plants and algae use to convert sunlight and $CO_2$ into energy.

### FOOD CHAIN

Represents the 'food' relationship between organisms and species in an ecosystem. For example, phytoplankton (tiny marine, plant-like organisms, which manufacture their own food using light) are eaten by fish, which are eaten by larger fish, which are eaten by humans.

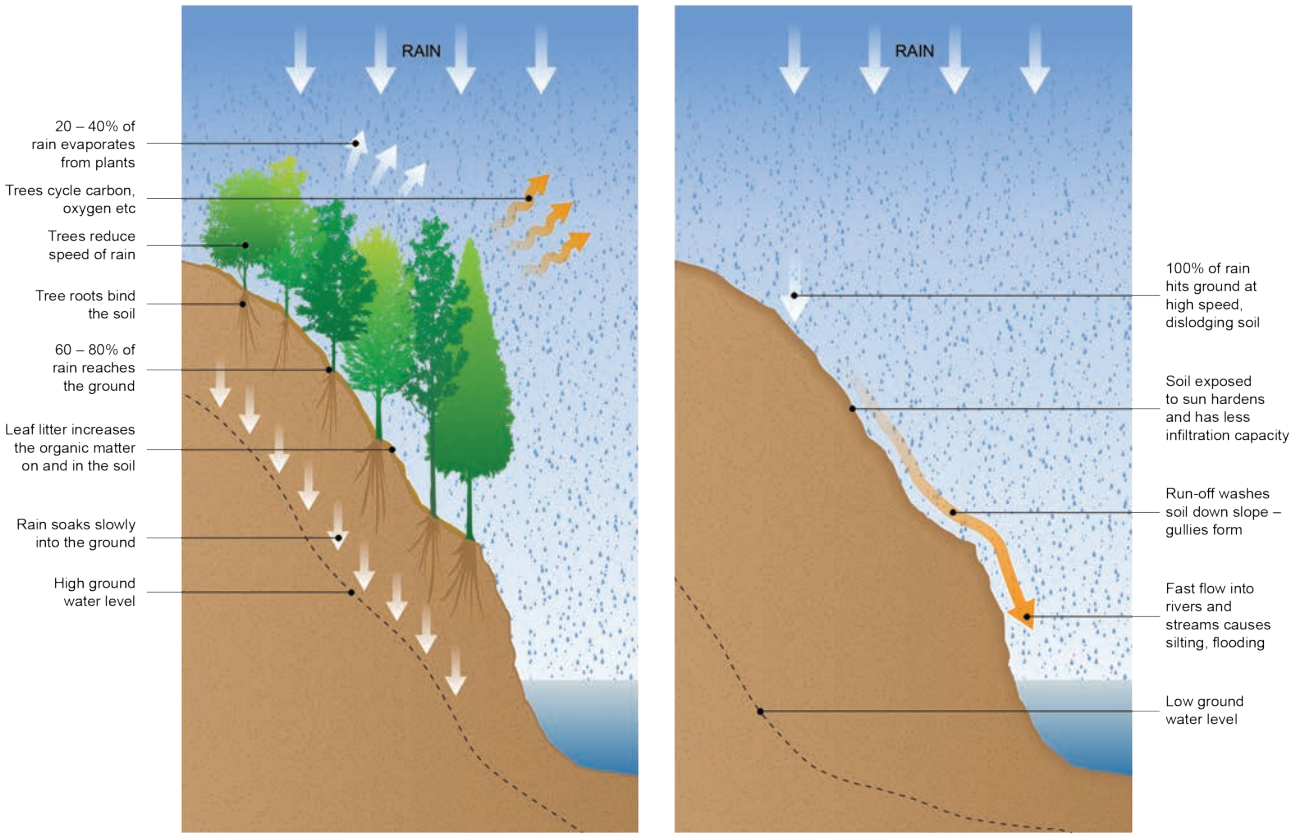
## Deforestation, Soil Erosion and Land Quality

The world's forests have major influences on the biosphere. Deforestation is the removal of trees from large areas of land, e.g. the Amazon basin in South America, and can lead to a number of negative environmental impacts.

## GLOSSARY

### BIOSPHERE

The part of the Earth and its atmosphere in which living things are found.




Some effects of deforestation

- Deforestation can contribute to climate change in the following ways:
  - Burning and decay of wood releases carbon dioxide into the atmosphere.
  - Trees and other plants photosynthesise - this involves removing carbon dioxide from the atmosphere to produce oxygen, thereby reducing atmospheric carbon-dioxide levels. If large forests are removed, less carbon dioxide is removed from the atmosphere.
  - The water cycle can be significantly affected. Trees take groundwater through roots, which is emitted into the atmosphere. When deforestation occurs, the lack of trees and other plants means that water is not evaporated and local climates are much drier.
- The cohesion of the soil is reduced by deforestation, resulting in:
  - Fertile agricultural soils being eroded.
  - Increased risk of landslides on steep slopes.
- A reduction in forest cover means that surface water run-off will increase, which may result in flash floods and increase the risk of localised floods compared with what would occur if the forest cover were present.
- Deforestation can result in a decrease in biodiversity. This can lead to a reduction in genetic variation. Genetic variation can lead to many agricultural benefits, such as development of crops that are resistant to pests, or have the ability to grow in poor-quality soils.
- Forests often contain many plants that are yet to be discovered, some of which may have properties that can be used to fight disease and ill health.

## GLOSSARY

### BIODIVERSITY

The number of plant and animal species present in an area.

For example, it is estimated that around 80% of the world's biodiversity is found in tropical rainforests.

Although short-term economic gains can be made from converting forested areas to agricultural land, or overly exploiting forests for wood products, if forests are not managed sustainably in the long term, deforestation will lead to a loss of long-term income.

**Shifting cultivation** ('slash and burn' agriculture) disrupts the forest ecosystem, particularly when it is on a large scale. Trees are cut from the soil, burned and the ash returned. Any nutrients are quickly leached away as they are contained only in the top few centimetres of the soil in tropical forests; therefore the cleared plots soon become infertile.

## GLOSSARY

### ECOSYSTEM

Refers to a community of interrelated species in a defined area.

Deforestation

## Material Resources and Land Despoliation

Access to land is vital to ensure the availability of food and to secure the livelihoods of poor rural populations. Land grabbing involves taking land for another use, such as intensive agricultural practices like palm oil production. This means that indigenous peoples, nomads, etc. have no (or reduced) access to food and livelihood security. Such activities will also capture water resources, meaning that people have no access to drinking water.

Land grabbing is often a non-sustainable model of land use, which:

- Causes forced evictions.
- Seriously affects the environment.
- Substantially reduces natural resources.

## Energy Supplies

Fossil fuels are attractive as an energy source. Being highly concentrated, they allow significant amounts of energy to be trapped in relatively small volumes. They also allow for easy distribution.

However, the adverse environmental impacts resulting from the combustion of fossil fuels are significant. They include:

- **Acid Rain**
  Acid gases resulting from fossil-fuel combustion combine with water vapour to create acid rain, which corrodes buildings, damages and kills trees and destroys life in rivers and lakes.
- **Smog**
  When gases from vehicle exhausts react with sunlight, smog is formed over cities, damaging trees and crops and affecting health.
- **Dwindling Resources**
  Fossil fuels cannot be rapidly reproduced. It takes millions of years to produce coal, gas and oil, and existing reserves will eventually run out.
- **Health and Welfare**
  Energy production from fossil fuels can have significant effects on health. Emissions from transportation include acute effects on certain people, e.g. streaming eyes, coughing, breathing difficulties and asthma attacks. Smog can irritate the lungs, cause bronchitis and pneumonia, and decrease resistance to respiratory infections.
- **Deforestation**
  Every year it is estimated that an area of tropical rainforest one and a half times the size of England is lost around the world. This removes a carbon sink and releases carbon dioxide into the air.

- **Climate Change**

  A number of greenhouse gases is emitted during the combustion of fossil fuels, the most significant being carbon dioxide.

- **Thermal Pollution**

  Heated water from fossil-fuel power production can have effects on the aquatic systems to which it is discharged.

## Waste Disposal and the International Waste Trade

The inappropriate storage, treatment, transport and disposal of waste can have numerous environmental impacts, including:

- Land contamination.
- Water pollution.
- Exposure of people to harmful substances.

Historically, numerous serious issues have occurred where waste has been exported from a developed country to one that has no facilities to treat or dispose of the waste in a manner that does not impact significantly on the environment and/or human health.

An international law has therefore been developed to control the international waste trade. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal requires that exporters of waste receive written consent from importing nations prior to the waste being transported. Various developing countries have gone further and banned imports of waste through their own policies or legislation.

### MORE...

More information on the Basel Convention is available at:

www.basel.int

## Agricultural Issues from Trade Between Developed and Developing Countries

Poor environmental practices can result from food and other products being grown in developing countries for export to developed countries. These problems are being driven by developed countries who, as such, have a responsibility for alleviating them. Such issues include:

- Clearing of forest and swamplands for cash crops.
- Using water for irrigating crops or watering animals that would be otherwise used by the local population.
- Use of harmful pesticides that may affect biodiversity and the health of the local population.
- Soil erosion leading to loss of fertile soil and reduction in downstream water quality.
- Fertiliser run-off, leading to poor water quality.
- Creation of poorly managed landfill facilities at agricultural sites.

One example where such trade creates many environmental and other issues is the global trade in palm oil. Palm oil is produced from the oil palm tree and is grown in countries in South East Asia, Central and West Africa and Central America. It is exported for use in a wide range of products, such as foodstuffs, personal-care products and biofuel. However, it has some significant impacts on the environment, such as driving deforestation, being a key cause of the demise of critically endangered species (such as the Sumatran orang utan and Asian rhinoceros) and destroying cash crops that are owned by indigenous people.

### REVISION QUESTIONS

1. List the three media that make up the 'environment'.
2. Briefly explain the terms 'greenhouse effect' and 'global warming'.

(Suggested Answers are at the end.)

# The Ethical, Legal and Financial Reasons for Maintaining and Promoting Environmental Management

## KEY INFORMATION

- The three main reasons why an organisation has to manage environmental impacts are: ethical (or moral); legal (or social); and financial (or economic).
- Key stakeholders for environmental management are local residents (including indigenous people), the supply chain, customers and employees.
- Pressure groups are organisations whose aim is to influence governments or businesses at local, national and international levels.
- Significant direct and indirect costs can occur from poor environmental management.

## TOPIC FOCUS

**General Benefits of Good Environmental Management**

An organisation can benefit in many ways if it maintains a high level of environmental performance:

- Better relations with communities local to an organisation by participation in local environmental schemes.
- Minimised energy costs.
- Decreased cost for managing wastes.
- Improved corporate image resulting in many business benefits.
- The organisation may be competitive on an international basis if it implements an environmental management system to internationally recognised standards, such as **ISO 14001**.
- Improved sales due to enhanced environmental performance of products or services.
- Opportunities for innovation, including improving existing products or developing new products.
- Reduction in the chances of an incident occurring that could cause significant environmental impacts.
- Provides for a better legal defence should an incident occur.
- Reduced insurance premiums.
- Improved access to finance, such as grants, loans and investments.
- Product with a minimal impact on the environment may stand out from other products.
- Improved staff recruitment to a reputable company that understands its environmental responsibilities.
- Reduced chance of incidents occurring leading to prosecution for breaches of environmental law.
- Reduced abatement control costs.

## RIGHTS AND EXPECTATIONS OF LOCAL RESIDENTS, INDIGENOUS PEOPLE, SUPPLY CHAIN, CUSTOMERS AND EMPLOYEES

Morally at least, people have a right to enjoy the environment around them. People (including employees) justifiably expect businesses (which may have a large pollution potential) to exercise reasonable care to ensure that they don't pollute the environment. If an environmental "incident" occurs (such as unreasonable noise in a residential area, unpleasant odour, littering, water pollution, etc.), the expectation is that the person responsible should discontinue, remediate and perhaps also compensate.

There is an expectation that:

- People should have a say in any proposed scheme that is likely to seriously affect their local environment (some of which will be covered under town and country planning legislation).
- Information on such matters should be accessible. (In relation to environmental information held by public bodies, specific laws exist.)
- Environmental information should be transmitted down the supply chain (so that people are informed about things such as environmental hazards, or responsible disposal of waste, and can take appropriate action).

### GLOSSARY

**REMEDIATE**

Repair the harm done to the environment by returning it to its unpolluted state. This could involve removing pollutants and could extend as far as restocking waterways with species affected by a pollution incident, or replanting damaged vegetation.

**SUPPLY CHAIN**

A chain of people, activities, operations and organisations that bring a product or service to the customer. It could involve, for example, those who: extract raw materials; transport the materials to manufacturers; manufacture the component parts; manufacture the final product; transport the final product to retailers; retail the final product to the customer.

There are many environmental pressure groups, customers and others who are quite prepared to boycott businesses for perceived irresponsible and unethical behaviour toward the environment.

### Indigenous People

It is estimated that there are around 370 million indigenous people in approximately 70 countries around the world. Indigenous people are those that existed before the arrival of people with different cultural or ethnic origins. Their economic, cultural and political practices are distinct from those of the main society in which they exist. Such groups around the world include the Mayas in Guatemala, Aborigines in Australia and the Maori in New Zealand.

Indigenous people in some areas of the world can be a neglected part of society, experiencing problems such as discrimination and lack of access to political representation, participation, or social services. As with any cultural group, they aim for recognition of their identity, ways of life and rights to land and natural resources.

## OUTCOMES OF INCIDENTS

Environmental incidents can have serious and far-reaching consequences, resulting in environmental and human harm and legal and economic effects on organisations. Below are examples of some major incidents resulting in such outcomes.

### Environmental and Human Harm

| Location and Year | Incident | Outcome |
|---|---|---|
| Minamata Bay, Japan, 1953-1960 | The Chisso Corporation's factory discharged methyl mercury in its waste water into the bay over a number of years. | The methyl mercury built up to high levels in fish. When contaminated fish were eaten by humans, it caused chronic mercury poisoning affecting the central nervous system, sensory impairment, numbness, dizziness, loss of vision and hearing, coma and, in some cases, death. It is thought to have affected more than 3,000 people. |
| Bhopal, India, 1984 | A leak of methyl isocyanate gas from the Union Carbide factory. | Killed 2,000 people and affected many more. Acute effects included burning in the eyes and respiratory tract, breathlessness, stomach pains, vomiting and choking, and pulmonary oedema. Many deaths resulted from choking. Many more people are thought to have died from the long-term consequences of exposure to the gas. |
| Chernobyl, Ukraine, 1986 | Overheating of a water-cooled reactor caused the release of radiation from a nuclear power plant. | 30 people were killed immediately. The radioactive particles spread across Scandinavia and Western Europe. Several thousand people could still die owing to the effects of the radiation. |
| Basel, Switzerland, 1986 | A fire at a chemicals factory resulted in fire water carrying mercury and pesticides into the river Rhine. | Half a million fish were killed and drinking water was contaminated and unusable. |
| Buncefield, UK, 2005 | A leak of petrol from an oil storage depot resulted in an explosion. | Much of the site and buildings in the vicinity were seriously damaged or completely destroyed. Drinking-water sources in the area were contaminated by fire-water run-off. No lives were lost. |
| Gulf of Mexico, 2010 | Explosion on the Deepwater Horizon oil well resulted in the spillage of five million gallons of oil into the Gulf of Mexico. | More than 100 miles of the USA's Louisiana coastline were affected and 11 workers on the rig died. More than 60,000 square miles were closed to fishing. Long-term economic and ecological effects are yet to be assessed. |

### Legal and Economic Effects on Organisations

There is a number of legal and economic effects on organisations responsible for environmental incidents:

- **Cost of Fines following Prosecution**
  Total, BP and Shell were fined a total of £5.35 million (around $8.3 million) for their involvement in the Buncefield oil-depot explosion. Another £4 million ($6.3 million) was awarded in costs.
- **Clean-Up Costs**
  These can extend to millions of pounds. Following the Deepwater Horizon oil-well explosion in the Gulf of Mexico, BP were reported to have spent $1 million just on containment of the spill. It is thought that final clean-up costs could amount to $6 billion.
- **Compensation Payments**
  In 2010, compensation payments for the losses suffered in the 2005 Buncefield oil-depot explosion had still not been settled. Much business disruption was experienced and individuals lost their employment and homes. It is thought that Total, BP and Shell face compensation payments of around £700 million ($1.1 billion).
- **Indirect Costs Resulting from Loss of Credibility and Support in the Market**
  - BP's share price plummeted following the explosion in the Gulf of Mexico.
  - It is difficult to estimate the loss to a company where customers choose to go elsewhere. Smaller companies are likely to face bankruptcy.

## THE ACTIONS AND IMPLICATIONS OF PRESSURE GROUPS

Pressure groups are organisations whose aim is to influence governments or businesses at the local, national and international levels. They can cover a single issue (and, as such, are often classed as 'cause'-based), or may cover multiple issues. Such groups change over time and they can be involved in numerous activities.

International environmental pressure groups include Greenpeace, Friends of the Earth, the International Union for Conservation of Nature (IUCN) and the World Wildlife Fund (WWF).

Some of the key ways that pressure groups exert influence include:

- Lobbying – discussing concerns with decision-makers, such as those involved in making law.
- Direct action – for example, Greenpeace influenced Shell Oil's attempt to dump the Brent Spar platform in the North Atlantic through occupation of the platform as it was being towed to its dumping point, and also staged protests at service stations.
- Publicity – pressure groups often try to generate as much publicity as possible for the issue in question in order to gain positive media attention.
- Legal action – pressure groups may fight their cause by legal means, inquiring about the legality of the issue.

The implications of pressure groups can be significant for organisations, as they may invoke the following responses:

- Reduced sales.
- Raising consumer awareness of an issue.
- Increasing the costs of a business through improved risk controls, etc.
- Changing current business practices.
- Influencing the making of law and government policy.
- Damaging the reputation of an organisation.

**MORE...**

Greenpeace - www.greenpeace.org/international/en

Friends of the Earth - www.foei.org

International Union for Conservation of Nature (IUCN) - www.iucn.org

World Wildlife Fund (WWF) - wwf.panda.org

## OVERVIEW OF LEGAL ISSUES

The law is a collection of rules designed to regulate and control the conduct of citizens, laid down by those in authority and enforced by its officials.

There is a strong body of international law that covers environmental issues. Environmental issues such as global climate change and ozone depletion, etc. do not recognise countries' borders. Often, countries will also develop their own laws that are based on compliance with international law, or include legal controls on other environmental issues. Groupings of sovereign countries, such as the European Union, may also be another influence on the laws that a country makes.

### Legal Rights of Individuals

The Universal Declaration of Human Rights was adopted by the United Nations General Assembly in 1948. Among other human rights it sets out the key legal rights of individuals:

- **Article 6**
  Everyone has the right to recognition everywhere as a person before the law.
- **Article 7**
  All are equal before the law and are entitled without any discrimination to equal protection of the law. All are entitled to equal protection against any discrimination in violation of this Declaration and against any incitement to such discrimination.
- **Article 8**
  Everyone has the right to an effective remedy by the competent national tribunals for acts violating the fundamental rights granted him by the constitution or by law.
- **Article 9**
  No one shall be subjected to arbitrary arrest, detention or exile.
- **Article 10**
  Everyone is entitled in full equality to a fair and public hearing by an independent and impartial tribunal, in the determination of his rights and obligations and of any criminal charge against him.
- **Article 11**
  (1) Everyone charged with a penal offence has the right to be presumed innocent until proved guilty according to law in a public trial at which he has had all the guarantees necessary for his defence.
  (2) No one shall be held guilty of any penal offence on account of any act or omission which did not constitute a penal offence, under national or international law, at the time when it was committed. Nor shall a heavier penalty be imposed than the one that was applicable at the time the penal offence was committed.

## PENALTIES FOR NON-COMPLIANCE WITH LAW

Non-compliance with law can lead to a number of sanctions, such as fines and, for more serious offences, imprisonment. In the UK for example, non-compliance with the **Environmental Protection Act 1990** (a key environmental law) can lead to an unlimited fine and/or two years in prison. Non-compliance may also lead to the polluter having to pay compensation to the person who has been wronged in relation to an environmental incident. Examples of compensation that might have to be paid include payment of the costs incurred for cleaning up an oil spill, or restocking a river with fish.

## DIFFERENT LEVELS OF STANDARDS

The top tier of law in many countries is that of international environmental law. International law can take many forms, including the following:

- **Treaty** – this term is used for matters of high importance that require a solemn agreement.
- **Convention** – describes a multilateral agreement with numerous parties. Conventions are usually open for participation by many nations, or the full international community.
- **Protocol** – generally, this is an agreement that is less formal than agreements using the terms 'treaty' or 'convention'. One type of protocol provides more detailed implementation of the general requirements of a convention. For example, the Montreal Protocol on Substances that Deplete the Ozone Layer 1987 provides further implementation of the Vienna Convention for the Protection of the Ozone Layer 1985.
- **Declaration** – this is a term used for numerous, usually non legally-binding, agreements made where the parties do not want to create a legally-binding agreement but do want to declare aspirations, for example the Rio Declaration on Environment and Development 1992.

The next level of law is that of a group of nations, often in a regional area. An example is the European Union. Types of European Law include:

- **Regulation** – applies directly to the intended target (normally member states). There is no requirement to assimilate into national laws.
- **Directive** – binding on EU member states with respect to the objectives to be achieved, but the method for achieving this is left open. Directives are normally implemented by national regulations made in each member state. They must be implemented by a defined date referred to in the directive.

Finally, individual nations will have some form of national (and possibly more localised) legal system in place. This may be influenced by the international legal systems covered earlier, but individual countries will have powers to implement other environmental laws as well, providing they do not contradict these two influences on the nation's legal system.

Such legal systems can differ substantially around the world. It is important that a good understanding of local legislation is gained in order to effectively manage environmental issues. The breach of environmental law is often a criminal offence and may result in a fine or a prison sentence.

As well as the criminal-law consequences, there is also the matter of compensation for those affected by environmental issues. Depending on the region/country concerned, this might involve taking legal action against the person who has caused the environmental problem through the civil legal system, and having to prove a negligent act has been carried out and was to blame for the incident.

The role of an environmentally responsible business is to ensure that, as a minimum, it complies with all the relevant environmental legal requirements. However, a progressive organisation will go beyond this and look at further improvements, all of which will help ensure its long-term success.

## THE BUSINESS CASE FOR ENVIRONMENTAL MANAGEMENT

It is possible to set out three main reasons for a business to actively and positively manage its environmental impacts:

- Moral or ethical.
- Legal.
- Financial.

These reasons are often not entirely separate, in that both moral and legal reasons result in a financial impact. However, it is worthwhile attempting to separate them to some extent for the purposes of examining the direct drivers behind them.

### Moral

The moral reasons for improving environmental performance are a mixture of social and ethical influences and can be summed up as 'doing what is right'. Every individual and every organisation will have a set of beliefs about what is right and how they believe they should go about doing their business. These beliefs will have been developed over time owing to a mix of social culture and pressures from others, such as the public and the media.

There is a number of stakeholders who play a significant part in developing the moral environment in which a business may function. Underlying these beliefs is the principle of sustainable development (discussed further below). It is increasingly important for businesses to take account of a wider range of stakeholders than may previously have been considered. This group now includes:

- **Consumers** - now more aware of both their impact on the environment and their ability to bring about change in large organisations when they act together.
- **Local communities** - are no longer willing to suffer pollution and other negative environmental or health effects for the sake of the potential increased prosperity a business may bring to an area.
- **Employees** - like working for an organisation with good environmental performance, and some organisations may use this as a factor in aiding recruitment and retention.
- **Insurance companies** - are likely to reward organisations with a good record in environmental management and which can show evidence of positive management of their impacts.

### Legal

The repercussions of failing to comply with relevant legislation can be severe for both companies and individuals. In the most serious cases, fines may be unlimited and individuals may be sent to prison for up to five years.

### Financial

Aside from the indirect financial impacts that may arise through the moral and legal routes, there are also direct financial benefits from a good standard of environmental performance.

The "Polluter Pays" principle that has been developed through the European Union provides a range of financial tools that can be used to encourage or force organisations to account for the pollution they create through the balance sheet. Some examples of these charges are:

- The **Climate Change Levy** applied to commercial fuel sources, such as coal, gas, electricity and Liquefied Petroleum Gas (LPG) - some of this income is used to fund organisations such as the Carbon Trust, which works with individuals and organisations to reduce their carbon emissions.
- The **Landfill Tax** applied to all waste deposited in landfill to encourage a movement away from the use of landfill as a means of disposal.
- The **Aggregates Tax** applied to virgin aggregates used in construction - this is designed to encourage the re-use and recycling of material in preference to the continued use of virgin material.
- Charges for Environmental Permits, etc., based partly on the level of pollution and partly on the standard of environmental performance recorded through the Operator Risk Appraisal (OPRA) scheme.

## Direct vs Indirect Costs

This is an often-used comparison for costs associated with health and safety. It is really the flip side of the business case for managing risks. Environmental costs are no different in this respect. These costs may be divided into two parts:

- **Direct Costs**

  These are the calculable costs arising from an accident and/or any claim for liability in the civil or criminal courts. They include:

  – repairs or replacement of damaged equipment and buildings;
  – remediation;
  – product loss or damage;
  – loss of production;
  – public and/or product liability;
  – fines;
  – legal fees; and
  – increases in insurance premiums.

- **Indirect Costs**

  These are costs that may arise as a consequence of the event, but do not generally actually involve the payment of money. They are often largely unknown, but it is estimated that, in certain circumstances, they may be extremely high. They include:

  – business interruption;
  – loss of orders;
  – cost of time spent on investigations; and
  – loss of corporate image.

## Insured vs Uninsured Costs

Employers will invariably take out insurance to cover themselves against potential losses caused by such events as fire and theft. They are also required by law to have insurance against certain types of liability (e.g. employers' liability insurance). However, many of the costs involved in respect of accidents are not covered by insurance.

Insurance varies, but there are often many exclusions in the small print. Uninsured costs usually include all indirect costs, as well as those relating to loss of production as a result of many types of incident. In addition, the insurance to cover loss in respect of certain events may be void where it can be shown that the employer has not taken adequate precautions to prevent the incident. Uninsured losses can be many times greater than insured losses.

### REVISION QUESTIONS

3. What are the three main reasons why organisations need to manage environmental impacts?

4. Identify three legal and economic effects that could occur following a pollution incident.

(Suggested Answers are at the end.)

## KEY INFORMATION

- Sustainability is a concept developed at the **Rio Earth Summit in 1992**.
- It is about the integration of several things:
  - Environmental protection.
  - Natural resources.
  - Social progress.
  - Sustainable purchasing.
  - Competition.
  - Economic growth.
- Indicators have been established to monitor the progress of environmental objectives.

## MEANING OF SUSTAINABILITY

The natural environment provides water to drink, air to breathe, food to eat and raw materials for making things - everything we need to live healthy and productive lives.

As we strive to become wealthier, environmental protection needs to be an integral part of social and economic development. If we damage the environment, or deplete stocks of natural resources in the process, future generations will find it harder to maintain the same standard of life that we currently enjoy.

Although we all want to be healthy and prosperous, it's important to achieve this in a sustainable way that does not irretrievably damage the natural resources of the Earth. In 1992, the UN held a landmark summit meeting at which the concept of sustainable development was first widely discussed. Following the summit, the UN Rio Declaration on the Environment and Development was issued. A frequently quoted definition of sustainable development is enshrined in Principle 3 of the Declaration:

> *"The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations."*

## IMPORTANCE OF SUSTAINABLE DEVELOPMENT

Sustainable development is a phrase that is often used, but the underlying concept not always understood. Sustainability can help an organisation develop and also contribute to global progress because it does so without depleting natural resources.

The idea of sustainable development arose from the realisation that our way of life is inherently 'unsustainable'. Environmental issues brought the first warning; we saw increasing loss of forests and wilderness areas, more animals and plants facing extinction, and the stock of fish in our oceans declining. We've also seen famines devastate huge areas in Africa, fuel shortages followed by a steep rise in fuel prices, and the increasing threat to the world's climate from global warming - all of which reinforce the idea that we are taking too much from the Earth.

We know that this situation cannot continue indefinitely. If we don't make significant changes - and soon - we will face a shortage of food, fuel, land, wild places, wild animals and plants, and other resources.

Sustainable development is about taking action to realign our economies with the capacity of the planet. There are several steps and organisation can take towards sustainability, they can endeavour to: protect the environment; use natural resources wisely; strive for social progress; use sustainable purchasing practices; be competitive; and maintain stable economic growth.

### Protecting the Environment

Our natural environment provides us with water, air, land to grow food, mineral resources, space and pleasant surroundings in which to live. Organisations that take effective steps to identify the potential environmental impacts of their activities and to protect the environment are therefore making an important contribution to sustainability. Key actions might include:

- Implementing an environmental management system.
- Designing products and processes that create less pollution.
- Meeting, or exceeding the requirements of environmental pollution legislation.

### Using Natural Resources Wisely

We've known for a long time that if we manage the naturally **renewable resources** available to us – such as fish in the sea, or timber in forests – we can maintain a sustainable supply. We can regularly harvest a proportion of the resource without depleting the supply - because that proportion will be replaced by natural growth. However, through modern fishing methods and indiscriminate clearing of woodland and forests for the growth of crops, we have gone far beyond the proportion of these resources which can be naturally restored. As a result, the supply of some natural resources is becoming very limited.

We also depend on many **non-renewable resources**, and using non-renewable resources in a sustainable way can be even more challenging. For example, one non-renewable resource we depend on heavily is oil. We use oil for fuel, and to make other materials, such as plastics.

There are several steps organisations can take to manage their use of non-renewable resources more sustainably:

- Using less energy.
- Designing products and processes that use fewer non-renewable-based (e.g. oil-based) resources.
- Finding renewable alternatives to the use of non-renewable resources (e.g. oil).
- Recycling non-renewable-based (e.g. oil-based) materials, such as plastics, wherever possible.

## Achieving Social Progress

In addition to the environmental and economic needs of mankind (present and future), sustainable development should also consider social well-being.

It's been proposed that a range of factors should be taken into account when measuring sustainability in the UK, including:

- Life expectancy.
- Poverty.
- Long-term unemployment.
- Social mobility.
- Housing provision.

We live and operate in a global market, so it's important to consider this concept on a wider scale. It's unreasonable to expect to achieve prosperity and high levels of well-being in the developed world if we cannot do so without decreasing the prosperity and well-being of workers in less developed areas. International trade must be fair and ethical, promoting social goals in the developing world.

There are steps organisations can take to ensure they're not contributing to poor conditions for workers, including ensuring:

- They do not purchase goods that are produced using child labour.
- Their workers all work in safe, healthy environments and receive fair wages.

**MORE...**

For information on the UK government's sustainable development programme:

www.gov.uk/government/policies/making-sustainable-development-a-part-of-all-government-policy-and-operations

## Sustainable Purchasing

Achieve sustainable development requires a dramatic change to the way we purchase products and services. By changing our purchasing policies, we can dramatically improve the sustainability of an organisation. Purchasing low-energy equipment is a good example of a win-win situation, where an organisation can reduce resource consumption while also saving money. A sustainable purchasing policy will result in many organisational savings and benefits, including:

- Reduced costs.
- Reduced in raw-material consumption.
- Reduced waste.
- Security of supply (e.g. by avoiding supplies of products that contain banned or dangerous substances).

It should also be recognised that there are potentially significant environmental and social risks associated with outsourcing particular activities. For example, certain manufacturing operations that are potentially highly polluting – like electroplating – may be outsourced to suppliers that do not operate to high standards of environmental management. Or the assembly of key components may be outsourced to a supplier in a developing country that uses child labour, or does not pay fair wages. A sustainable purchasing programme will ensure that potential suppliers of goods or services meet required standards.

## Being Competitive

There are various ethical arguments in support of adopting a sustainable development path. However, it's not just an ethical issue; being responsible and accountable can also have significant commercial advantages. Awareness of, and concerns related to, environmental protection and ethical trade are becoming widespread. It's important for organisations to react to this shirt and recognise that:

- There's a huge investment market which will only consider ethically sound companies. These Socially Responsible Investment (SRI) funds use corporate responsibility performance measures to help them choose well-run companies to invest in.
- Customers not only understand, but also care about environmental and fair-trade issues; they're willing to support initiatives such as the Forest Stewardship Council (FSC), which promotes products made from wood grown in sustainable forests.

As a result, organisations can benefit from a sustainability strategy for a number of reasons. They may enjoy:

- Reduced operating costs, e.g. as a result of increased energy efficiency and reduced waste production and water usage.
- Better access to capital, e.g. from investors who value sustainable business practices and recognise the advantages of these policies.
- Improved reputation, and therefore sales, from customers who appreciate the importance of supporting sustainable business and want to be confident that the products they purchase have been produced in an environmentally and socially responsible way.

## Maintaining Stable Economic Growth

The economic argument tends to be very important to organisations, but economic growth is also important to our well-being. It's important to us to be able to enjoy life, in addition to meeting our more basic needs for clean water and food, etc. Ensuring stable economic growth for the future is essential for our own well-being and the well-being of future generations, but this can raise serious questions regarding sustainability.

Some believe that growth implies that we will continue to consume more and more resources - which is incompatible with the central objective of sustainability. Others believe this is a misunderstanding and 'economic growth' should be re-defined to avoid the implications associated with the current definition, which is an increase in monetary Gross Domestic Product (GDP).

It's been suggested that a better target in terms of a sustainable economy would be to change our lifestyle, by:

- Consuming fewer resources.
- Having less money, and relying on stronger communities and less stressful lifestyles.
- Reducing the financial inequality across all members of our society.

## Corporate Social Responsibility

Corporate Social Responsibility (CSR) is an organisational approach that is very closely aligned with the concepts of sustainability. Organisations that pursue CSR seek to embed social, environmental and ethical management at the heart of their businesses. CSR requires that an organisation should be accountable to its stakeholders – customers, investors, employees, suppliers, local communities and society as a whole – for managing its social, environmental and wider economic impacts.

Many companies now produce regular CSR reports that cover the three main strands of environmental, social and economic sustainability:

| | |
|---|---|
| **Environmental** | • Resource consumption<br>• Control of pollution<br>• Energy and climate change<br>• Biodiversity<br>• Supply chain impacts |
| **Social** | • Working conditions<br>• Fair wages<br>• Diversity |
| **Economic** | • Socially responsible investment<br>• Fair contracts and pricing<br>• Trading with emerging economies<br>• Taxes and subsidies |

A consensus is emerging on good reporting practice, and standards have now been developed to guide reporting organisations, notably the international Global Reporting Initiative.

### MORE...

Recent examples of corporate environmental reports, together with the latest reporting guidelines, can be found on the Global Reporting Initiative (GRI) website:

www.globalreporting.org/reporting/Pages/default.aspx

### REVISION QUESTION

5. Explain why achieving sustainable development is difficult.

(Suggested Answer is at the end.)

## KEY INFORMATION

- There is an international framework for environmental law, as some environmental issues require international co-operation.
- Best available technique is a key principle in pollution assessment and control.
- Enforcement agencies play a key role in environmental management and often have powers to issue permits, inspect sites, serve notices and prosecute.

## INTERNATIONAL LAW

International environmental law comprises the body of rules derived both from international agreements and customary international law to which sovereign states have expressly or implicitly (via state practice) consented.

International environmental law is often in the form of **Conventions**, which are legally binding agreements between a significant number of different states, often developed under the auspices of the United Nations. Conventions are often implemented through subsidiary **Protocols**. The **Vienna Convention for the Protection of the Ozone Layer (1985)**, for example, is implemented through the various amendments to the **Montreal Protocol on Substances that Deplete the Ozone Layer**, which sets the detailed timetable for phasing out production of ozone-depleting substances. A number of the most significant international Conventions and their subsidiary protocols is summarised in the table below:

International Conventions and Protocols on the Environment

| Subject | Convention | Subsidiary Protocols |
|---|---|---|
| **Climate change** | United Nations Framework Convention on Climate Change 1972 | Kyoto Protocol 1997;<br>Doha Amendment 2012 |
| **Protection of the ozone layer** | Vienna Convention for the Protection of the Ozone Layer 1985 | Montreal Protocol 1989<br>Latest revision – Beijing 1999 |
| **Air pollution** | Convention on Long-range Transboundary Air Pollution ('Geneva Convention') 1979 | Oslo Protocol 1994<br>Aarhus Protocol 1998<br>Gothenburg Protocol 1999 |
| **Marine pollution** | Convention for the Protection of the Marine Environment of the North-East Atlantic ('OSPAR Convention') 1992 | |
| **Hazardous wastes** | Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal ('Basel Convention') 1992 | Basel Protocol 1999 |
| **Persistent organic pollutants** | Convention on Persistent Organic Pollutants ('Stockholm Convention') 2001 | |
| **Habitat protection** | Convention on Wetlands of International Importance ('Ramsar Convention') 1971 | Paris Protocol 1982 |

We will now take a look in more detail at a number of these key international legal requirements.

## Ozone Depletion

The **Vienna Convention 1985** required nations to take appropriate measures to protect people and the environment against the impacts resulting from human activities that modify, or are likely to modify, the ozone layer. The main aim of the convention is to ensure that countries undertake research, exchange information and monitor CFC production. The convention acts as a framework for international efforts to combat ozone depletion.

More specific requirements on the banning and phasing out of Ozone-Depleting Substances (ODS) are present in the **Montreal Protocol on Substances that Deplete the Ozone Layer 1987**. Since its initial opened for signatures in 1987 (coming into effect in 1989), the protocol has undergone seven revisions. This has resulted in the phase-out date for ODS as identified in the table below:

| Ozone-Depleting Substance | Developed Countries Phase-Out Dates | Developing Countries Phase-Out Dates |
|---|---|---|
| CFCs | 1995 | 2010 |
| Halons | 1993 | 2010 |
| Methyl Chloroform | 1995 | 2015 |
| Carbon Tetrachloride | 1995 | 2010 |
| HCFCs | 2020 | 2030 |
| HBFCs | 1995 | 1995 |

### MORE...

Further information on the Montreal Protocol can be found at:

http://ozone.unep.org/new_site/en/montreal_protocol.php

## Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal

As we saw earlier, this law aims to prevent the transfer of hazardous waste from developed countries to less developed countries. It aims to control international waste movements by requiring that exporters of waste receive written consent from importing nations prior to the waste being transported. The convention also places a ban on the exportation or importation of waste between those who are party to the convention and those who are not. There are, however, exceptions where a country is subject to a treaty or similar that does not undermine the Basel convention. For example, the USA is a non-party to the convention but has developed a number of agreements allowing for shipping of hazardous waste to those countries that have ratified the Basel convention.

### MORE...

As stated earlier, more information on the Basel Convention is available at:

www.basel.int

## Ramsar Convention

The Convention on Wetlands of International Importance, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international co-operation for the conservation and wise use of wetlands and their resources. The convention covers many types of wetlands such as swamps, marshes, lakes, deltas, tidal flats and mangroves. The aims of the convention are achieved through the implementation of ecosystem approaches within the context of sustainable development. Those who are party to the convention must:

- Work towards the wise use of wetlands through land-use planning, policies and law.
- Designate suitable wetlands for the list of wetlands of international importance (the Ramsar sites list) and ensure that they are effectively managed.
- Internationally co-operate with regard to transboundary wetlands, shared wetlands systems, and development that poses a significant risk to wetlands.

### MORE...

More information on the Ramsar Convention is available at:

www.ramsar.org

## OSPAR Convention 1992

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention) entered into force in 1998 and has been ratified by 15 countries and the European Union (under decision **98/249/EC**). It works by identifying threats to the marine environment in the north-east Atlantic and programmes and measures that ensure national action is taken to combat them. It sets internationally agreed goals and monitors them to ensure that countries are complying with them.

This part of the Atlantic is under intense pressure with regard to the marine ecosystem, pollution, maritime activities, oil and gas extraction and nuclear energy. Achievements since the convention's introduction include:

- Significant reduction in phosphorous and heavy metals.
- Reductions in discharges from nuclear plants.
- Ban on waste dumping.
- Network of OSPAR marine-protected areas.

### MORE...

More information on the OSPAR convention is available at:

www.ospar.org

## THE ROLE OF THE EUROPEAN UNION IN HARMONISING ENVIRONMENTAL STANDARDS

A significant role of the European Union (EU) is to break down economic and commercial barriers between member states. It therefore has a major role in determining legislation in member states. The extent of control a member state has with regard to environmental law-making is as follows:

- A member state is able to determine the subject, content and form of its national legislation.
- A member state can enact its own legislation independent of the EU, provided it does not contradict an EU Directive. In practice, this would probably mean setting a higher standard.
- As a consequence, member states tend to respond only to the EU Directives and do not formulate their own laws when the EU may well issue a later Directive with different requirements.
- The Directives are binding on the result to be achieved, so that gives members states some leeway in interpretation and enactment to suit their own legal systems.
- The EU sometimes enacts a Regulation (rather than a Directive). An EU Regulation is binding on member states in its entirety; they have no choice about how to implement it.

The process responsible for the creation of instruments of EU law can be influenced by a member state's representation on the main EU institutions.

## MEANING OF BAT AND BPEO

**BAT (Best Available Techniques)** applies to industrial installations that require an integrated pollution prevention and control permit to operate under **Directive 2010/75/EU** on industrial emissions (integrated pollution prevention and control).

In the context of BAT:

- "Best" means, in relation to techniques, the most effective in achieving a high general level of protection of the environment as a whole.
- "Available Techniques" means those techniques that have been developed, on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the cost and advantages, whether or not the techniques are used or produced inside the member state in question (as long as they are reasonably accessible to the operator).
- "Techniques" includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.

A related concept is that of **Best Practicable Environmental Option (BPEO)**, which has very wide application. It is a holistic approach like BAT, aimed at avoiding situations in which narrow thinking to limit pollution to one medium could, in fact, increase pollution to another medium. Therefore, the environment as a whole is considered. The concept can be defined as:

> *"the outcome of a systematic consultative and decision-making procedure which emphasises the protection and conservation of the environment across land, air and water. The BPEO procedure establishes for a given set of objectives, the option that provides the most benefits or the least damage to the environment, as a whole, at acceptable cost, in the long term as well as in the short term."*
>
> (Source: UK Royal Commission on Environmental Pollution)

## THE ROLE OF ENFORCEMENT AGENCIES AND CONSEQUENCES OF NON-COMPLIANCE

There is no harmonised global standard for the enforcement of environmental law, so legal and enforcement systems vary between countries. There are, however, some general principles that normally apply.

Each country or region has one (or more) enforcement agency responsible for enforcing environmental law. Such an agency is effectively the "environmental police force". In some circumstances, the agency may be, or may enlist the help of, the national or regional police.

These agencies often:

- Provide advice.
- Investigate environmental incidents.
- Take formal enforcement action to force organisations to comply with the law.
- Start criminal proceedings against persons or organisations they believe have committed offences.

Enforcement agencies are also often involved in authorising activities that can have an impact on the environment. This usually takes the form of an environmental permit (depending on the legal system of a country, this may alternatively be called a consent, licence or authorisation, as there is no worldwide standard terminology used). An environmental permit will set conditions on activities that could impact on the environment. For example, in many countries before an organisation may discharge potentially polluting materials to rivers, streams and other types of watercourses they will have to apply for a permit. If the permit is granted it will set limits on polluting parameters associated with the discharge, such as pH, suspended solids and heavy metal, etc. Other activities that are often permitted in many countries include:

- Discharge to groundwater.
- Keeping, treating and disposing of waste.
- Emissions of pollutants to air.
- Integrated permits (where more than one activity is controlled by a single permit).

An enforcement agency will often be tasked with undertaking inspection of workplaces to check compliance with environmental legislation. However, as resources are often limited for governments to fund such inspections, it is often the case that sampling is used. In this context, organisations that present a high environmental risk owing to the activities that they undertake will be inspected more frequently than those that present a low environmental risk.

### Consequences of Non-Compliance

A breach of environmental legislation is usually a criminal offence – wherever you are in the world. Failure to meet legal standards might lead to:

- Formal enforcement action: an enforcement agency might force an organisation either to make an improvement within the workplace or to stop carrying out high-risk activities through the issue of a notice. The notice will usually state what action is needed and the timeframe for implementation. Failure to comply with a formal enforcement notice is usually considered to be an offence in itself.
- Prosecution of the organisation in the criminal courts: successful prosecution might result in punishment in the form of a fine.
- Prosecution of individuals, such as directors, managers and workers: successful prosecution might result in punishment in the form of a fine and/or imprisonment.

As stated earlier, as well as the criminal-law consequences there is also the matter of compensation for those affected by an environmental incident. Depending on the region/country concerned, this might involve:

- Those wronged taking legal action through the civil legal system and having to prove that the organisation had been negligent and is to blame for the incident.
- Claiming compensation from national or regional compensation schemes, with no requirement to prove negligence or blame through the use of the legal system.

### REVISION QUESTIONS

6. State the international laws that cover:
   (a) Protection of the ozone layer.
   (b) Protection of wetlands.
7. Define 'BPEO'.
8. Around the world, what types of activities are environmental permits often required for?

(Suggested Answers are at the end.)

# Summary

## SUMMARY

This element has dealt with some of the basic principles of environmental management.

In particular, this element has:

- Explained that environmental management covers a wide range of disciplines, e.g. physics, chemistry, biology, geology and engineering but also town and country planning, public health and legislation.
- Outlined organisational barriers to good standards of environmental management, including the complexity of the environment, conflicting and competing demands, and behavioural issues.
- Described key environmental issues of concern, including local effects of pollution; carbon emissions and climate change; air pollution and the ozone layer; water resources; deforestation; soil erosion and land quality; land grabbing; energy supplies; waste disposal and the impacts of agriculture.
- Explained three main reasons for an organisation to actively and positively manage its environmental impacts:
  - Moral/ethical - "doing what is right".
  - Legal - importance of complying with relevant legislation.
  - Financial - the "polluter pays" principle provides a range of financial tools to encourage organisations to account for pollution through the balance sheet.
- Referred to the pillars of sustainable development: environmental protection, natural resources, social progress, sustainable purchasing, competition, economic growth.
- Explained how enforcement bodies work with industry to prevent and reduce pollution. Through a network of inspectors, they are responsible for inspecting processes and sites that are permitted, in order to ensure permit conditions are complied with.
- Outlined the options available to the regulating authorities when enforcing legislation, including use of notices and prosecutions.

## INTRODUCTION


To achieve the NEBOSH Environmental Certificate qualification you need to perform well during the exam. 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.
- Your success in applying that knowledge to 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. After this, you will find an Exam Skills question for you to answer; similar questions can be found at the end of each element.

### EXAM REQUIREMENTS

The 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:

- half an hour on Section 1; and
- one-and-a-half hours on Section 2 (nine minutes per question).

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 a basic approach can be adopted, which formalises the answering of exam questions:

- **Step 1: READ THE QUESTION**
  Ensure that you read the full question – triggers and clues can often be in the second half of the question.
- **Step 2: REVIEW THE MARKS**
  Should a question be worth eight marks then the examiners will expect to see eight pieces of information. Some questions are split into sub-parts, with marks allocated accordingly. Ensure that you read the marks available carefully, as this will provide a guide to the length of time to be spent on each answer, in addition to how much should be written.

### COMMAND WORDS AND THEIR MEANINGS

- **Step 3: HIGHLIGHT THE KEY WORDS**
  Key words are those in a question that are essential in determining the meaning of the question. So, for example, if the question was "Give the meaning of the term Eco Management and Audit Scheme", you could say that the key words are:
  - **Give** – that is what you are being asked to do - provide the meaning of a word or phrase.
  - **Eco Management and Audit Scheme** – this is the phrase for which you must provide the meaning.

  The verb or action word in each question is quite important. Below are a few of the most commonly used instructions with a translation of their meaning:
  - **Identify** – give reference to an item, such as its name or title.
  - **Give** – offer for acceptance, consideration or use by another.
  - **Outline** – give the key features of. You need to give a brief description of something or a brief explanation of reasons why. A great amount of depth and detail is not required.
  - **Describe** – provide an in-depth description of what the thing is, what it looks like, how it works, etc. For 'Describe' questions a great amount of detail is needed.
  - **Explain** – provide a detailed explanation - reasons why, reasons for, how it works, etc. Again, a great amount of detail is required.

EXAM SKILLS PRACTICE

- **Step 4: READ IT AGAIN**
  To check again that you have understood the meaning of the question.
- **Step 5: PLAN YOUR ANSWER**
  Consider jotting down a brief answer plan prior to starting your answer. A logical answer is expected - writing a plan will help achieve this. Jotting down key words for the plan will also help you recall information associated with key words.

  The form of an answer plan can vary. A structured list can be used, similar to the contents page of a book or report. Another approach is to use a mind map (which is often used as a revision aid as well). Don't worry about what a plan looks like - its purpose is to allow the listing of ideas as they occur in the mind and to provide structure to ideas.

At the end of each element there are Exam Skills questions for you to attempt, with guidance on how to answer, in addition to a suggested answer outline.

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.

You will see 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.


## QUESTION

Taking into account what we have just covered on exam technique, consider the following exam-style question.

(a) **Give** the meaning of the term "environment". (2)

(b) **Explain** the key barriers that an organisation may encounter when wanting to improve its environmental performance. (6)

### APPROACHING THE QUESTION

Using the system we have covered, the first thing to do is read the question.

- Next consider the marks available. In this question, there are eight marks, so it is expected that eight different pieces of information should be provided – two for part (a) and six for part (b) – and the question should take around nine minutes.
- Now highlight the key words. In this case, these would be 'give' and 'environment' for part (a) and 'explain', 'barriers', 'improve environmental performance' for part (b).
- Read the question again – make sure you understand it.
- The next stage is to develop a plan. Remember, a plan can be completed in various ways, but using the general outline approach it could consist of the following:

  (a) Surroundings, extension to global system.
  (b) Complexity, conflicting demands, behavioural issues.

In order to ensure your answer is relevant it must be based on the key words you have highlighted. So, in this case, for part (a) your answer must give the meaning of environment and for part (b) your answer should cover the relevant barriers to a good standard of environmental management.

Now have a go at the question - as it's the first question you're attempting on the course, write the answer in bullet-point form rather than to the depth that would be expected in the exam.

### SUGGESTED ANSWER

Now you have finished your answer, read the suggested answer below and compare it to your answer.

(a) The meaning of environment in the ISO 14001 standard is: "surroundings in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans and their interrelation. **Note**: Surroundings in this context extend from within an organisation to the global system."

(b) The first barrier is complexity. Organisations and associated environmental issues can be complex; deciding which impact to tackle and ways of achieving improvement require knowledge of environmental management – particularly in terms of understanding options for improvement.

Competing and conflicting demands present another barrier. Organisations must make a profit to survive and this can be seen as the main driver for an organisation, whether or not the organisation's activities cause a significant impact to the environment.

Behavioural issues also present another challenge. The way people behave at work can be very difficult to change. As such, if change is made it can take time, and good reasons must be provided to people in order for them to make changes.

# ENVIRONMENTAL MANAGEMENT SYSTEMS

ELEMENT 2

## LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Identify the reasons for implementing an Environmental Management System (EMS).
2. Describe the key features and appropriate content of an effective EMS, i.e. **ISO 14001:2015**.
3. Identify the benefits and limitations of introducing **ISO 14001/EMAS** into the workplace.
4. Identify key members of the **ISO 14001** family of standards and their purpose.

# Contents

# Reasons for Implementing an Environmental Management System (EMS)

## KEY INFORMATION

- There is a number of reasons for implementing an environmental management system.
- These include:
  - Demonstrating management commitment.
  - Having common management principles with other systems.
  - Responding to stakeholder pressure.
  - Acting in a socially responsible way.

Many organisations want to improve their environmental performance, but find it difficult to know how to go about this in an effective and efficient manner. We have seen that any organisation can have many different interactions with the environment. Deciding which issues should have priority, and exactly what needs to be done to address these, is not always easy.

Environmental management systems are tools that help organisations manage their environmental issues systematically and comprehensively. The EMS model set out in the international **ISO 14001** standard is now the most widely adopted. This is based on the Total Quality Management concepts that underpin other commonly implemented management systems (notably the **Quality Management System ISO 9000**) and where the emphasis is on continual improvement.

Organisations that follow this EMS approach can enjoy a number of benefits. For example, they can:

- Manage their environmental impacts in the most resource-efficient way to bring about improvements.
- Make cost savings through better control of such issues as energy consumption and waste management.
- Achieve compliance with environmental legislation.
- Demonstrate their environmental commitment to customers and other interested parties, such as regulatory authorities, insurance companies, shareholders and local residents.

## DEMONSTRATING MANAGEMENT COMMITMENT

Implementing an EMS is a significant undertaking and cannot succeed without commitment from senior management because:

- It can be a time-consuming task requiring potentially significant use of resources in terms of time, money and facilities.
- The person or team implementing the EMS will need to call on expertise from many people in the organisation. If the EMS is not seen as an important issue then these people may not be willing to give the time necessary to gather the correct information. For instance, a production manager will be crucial to gaining information on the production process, the environmental impacts it may have and the potential for changes to reduce those impacts. If the production manager does not give his/her time, then valuable information will not be collected.
- There must be a clear message to the rest of the organisation that this is an organisational priority.
- The benefits to the organisation of implementing the EMS must be explained and understood by all to gain support.

Successful implementation of an EMS demonstrates to the public, customers, employees and other stakeholders that management are committed to environmental performance.

## GLOSSARY

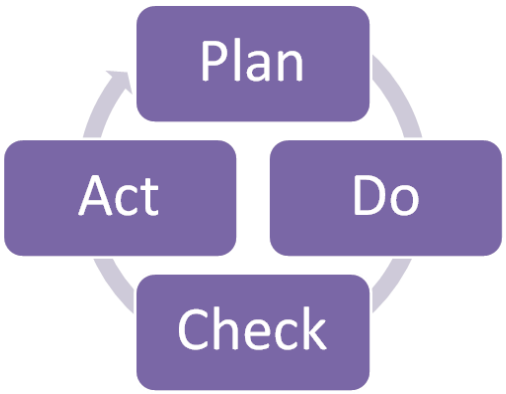
### STAKEHOLDERS

Those with an interest in your company, e.g. customers, shareholders, regulatory authorities, residential neighbours, insurance companies and the supply chain.

# Reasons for Implementing an Environmental Management System (EMS)

## SHARING OF COMMON MANAGEMENT SYSTEM PRINCIPLES WITH QUALITY AND HEALTH AND SAFETY MANAGEMENT

Quality, environmental and health and safety management are all based on a common platform and share the same structure. A way to effectively manage them is by following the Plan-Do-Check-Act (PDCA) cycle (see later). It is quite possible to integrate the management of the three disciplines into a single management system, which can represent significant savings to an organisation. It is, however, highly unlikely that a single person will have sufficient knowledge and experience in all these areas to effectively manage the entire system, and you should not underestimate the need for specialist knowledge in these areas.




## STAKEHOLDER PRESSURE (CUSTOMER/ REGULATORY INFLUENCE)

Some powerful customers can exercise huge influence over suppliers – making it difficult to become an 'approved supplier' (or retain this status) unless an EMS is in place (formal or otherwise). You may be familiar with the 'approved supplier' questionnaire, where you can either painlessly tick the box on the front, confirming that you have a formal, certificated EMS, or fill in a 60-page supplier questionnaire, which asks detailed questions about the informal EMS that you may or may not have. This 'pushing back' onto suppliers is all part of exercising greater control over the inputs into the organisation. Regulators must also be satisfied – the granting of an Environmental Permit effectively requires at least some elements of an EMS to be in place.

## CORPORATE SOCIAL RESPONSIBILITY

As we have seen, organisations that pursue CSR seek to embed social, environmental and ethical management at the heart of their businesses. Implementing a formal EMS is wholly compatible with this approach, and an EMS can be an important element of an overall CSR programme.

## REVISION QUESTION

1. Why is management commitment so important when implementing an environmental management system?

(Suggested Answer is at the end.)

# The Key Features and Appropriate Content of an Effective EMS

## KEY INFORMATION

- Environmental Management Systems follow standard 'Plan, Do, Check, Act' principles, with an ultimate aim of achieving continual improvement in environmental performance.
- The main components of **ISO 14001** are: context of the organisation, leadership, planning, support, operation, performance evaluation and improvement.
- Active and reactive measures for monitoring performance are available.

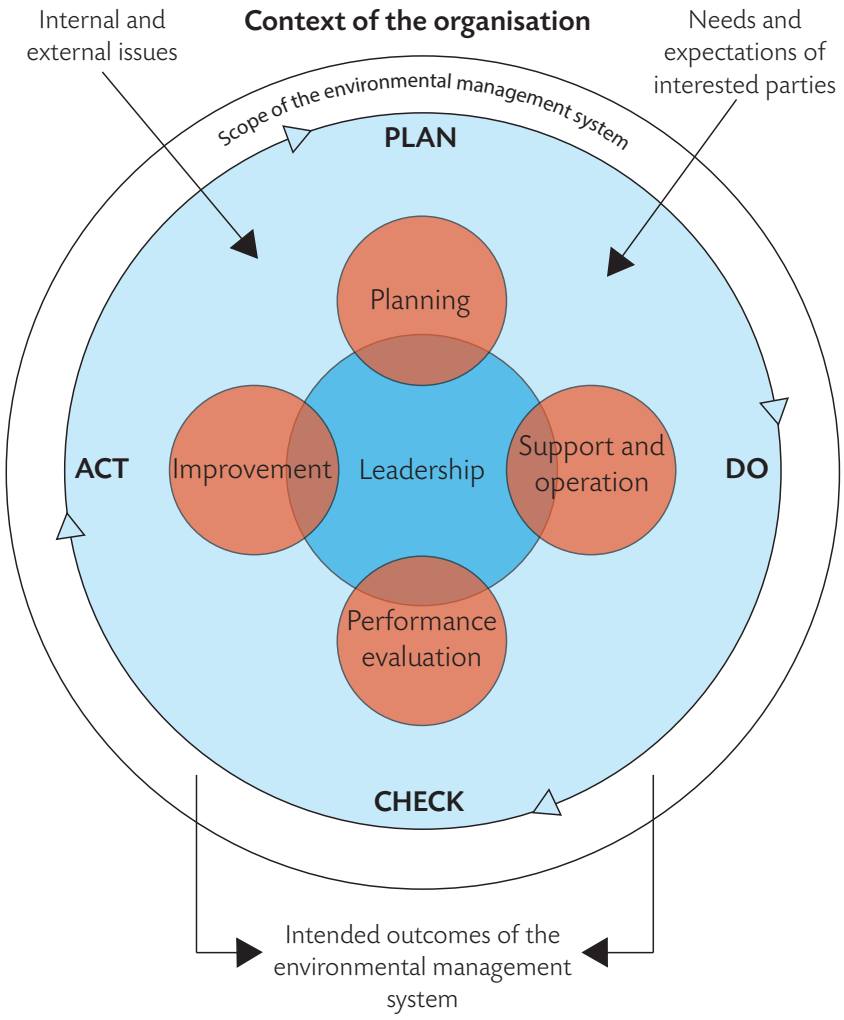
In this section we're going to consider an effective environmental management system based on the requirements of **ISO 14001**.

**ISO 14001:2015** is a development of earlier versions (from 1996) and aligns more closely with other standards, such as **ISO 9001** (Quality Management Systems).

**Note:** You should be aware that the **ISO 14005** standard offers a phased implementation approach to EMS implementation. However, it has been criticised for its complexity in comparison to **BS 8555** (an alternative guide) and, as such, has been rejected by the European Standards Board (CEN).

In common with nearly all management systems, the **ISO 14001** standard follows the basic steps of the so-called Deming cycle (**Plan-Do-Check-Act**). This cyclical process is designed to ensure a process of continual action and improvements towards a set of objectives.

## ISO 14001




ISO 14001 management system process

## TOPIC FOCUS

The key steps in the implementation of an EMS that conforms to the **ISO 14001** standard are:

**1. Context of the organisation**

An organisation must understand all relevant issues that may affect or is affected by the organisation. The scope of the EMS must be determined and documented.

**2. Leadership**

Top management must demonstrate leadership. Roles and responsibilities should be assigned and a compliant environmental policy produced.

**3. Planning**

Key action includes the identification of relevant aspects and impacts of the organisation on the environment. The organisation must also set objectives and understand its compliance obligations.

**4. Support**

Resources must be made available to develop and operate the EMS. Requirements are also stated for competency, communication and documented information.

**5. Operation**

Consistent with a life cycle perspective the organisations must develop operational controls. Emergency plans must also be developed and tested where appropriate.

**6. Performance evaluation**

An organisation must monitor, measure, analyse and evaluate its environmental performance. Requirements are also present to develop and implement internal audit programmes. Top management must also review the EMS at **suitable intervals.**

**7. Improvement**

The cause of nonconformances must be eliminated. Nonconformances should be prevented from happening again.

## INITIAL ENVIRONMENTAL REVIEW

Where there is no existing EMS, it is recommended that an Initial Review is undertaken to establish the organisation's current position with regard to the environment. The review should cover all of the activities of the organisation that are within the scope of the management system, for example:

- The main and ancillary processes.
- Transport to, on and from the sites.
- Raw and intermediate material handling, storage and transfer activities.
- Waste-material storage, transfer and disposal arrangements.
- Maintenance activities.
- Packaging and warehousing.
- Procurement services and the engagement and supervision of contractors and service providers.
- The planning and design of new buildings, equipment, processes, products and services.

The review should cover four key areas:

1. The identification of environmental aspects and the evaluation of significant environmental impacts and liabilities.
2. The identification of compliance obligations (these might be legal requirements and other requirements e.g. industry codes of practice; customer requirements; holding company requirements).
3. Examination of existing environmental management practices and procedures.
4. Assessment of previous incidents, complaints and non-conformances.

The review may also include:

- An assessment of potential commercial benefits, such as reduced energy, waste disposal and raw material costs.
- The views of key stakeholder groups (e.g. local residents, regulators, major shareholders).

The review should enable an organisation to answer the question: "Where are we now?"

## CONTEXT OF THE ORGANISATION

Initially an organisation must understand its context. This includes internal and external relevant issue such as the environmental conditions that may be affected by the organisation or environmental conditions that could affect the organisation. Part of this phase of ISO 14001:2015 also requires that the needs and expectations of interested parties are fully understood.

The scope of the EMS must be determined and documented and made available to interested parties. The scope needs to include various issues such as compliance obligations, activities products and services that the organisation undertakes/offers in addition to what it can control and influence.

ISO 14001 requires that an organisation establish, implement, maintain and continually improve an ISO 14001 compliant environmental management system.

## GLOSSARY

### MANAGEMENT SYSTEM

Set of interrelated or interlacing elements of an organisation to establish policies and objectives and processes to achieve those objectives.

### ENVIRONMENTAL CONDITIONS

State or characteristic of the environment at a set point in time.

### ENVIRONMENTAL MANAGEMENT SYSTEM

Part of the management system used to manage environmental aspects, fulfil compliance obligations and address risk and opportunities.

### PROCESS

Set of interrelated or interacting activities which transform inputs into outputs. A process may or may not be documented.

## LEADERSHIP

Top management must demonstrate leadership and commitment to the EMS. Examples of how this can be achieved are by being held accountable for the EMS, ensuring that the EMS is fully integrated into the organisation and promoting continual improvement.

Environmental roles and responsibilities must be assigned and communicated by top management in order to comply with ISO 14001. Every employee should be made aware of their responsibility in achieving compliance with the policy and specific requirements of the EMS that are relevant to them. Responsibilities can be stated in numerous ways and may be integrated

with other job roles in job descriptions and/or a section in the environmental manual.

It should be noted that organisational structures are different in different organisations; however, a sample list of responsibilities is provided in the following table:

Sample environmental responsibilities

| Example Environmental Responsibilities | Responsibility |
|---|---|
| Identify overall direction of the EMS. | Chief Executive/ Managing Director. |
| Design policy. | Chief Executive/ Managing Director/ Environmental Manager. |
| Identify environmental objectives, targets and programmes. | Departmental Managers. |
| Monitor EMS performance. | Environmental Manager. |
| Identify training needs/ Retain training records. | Environmental Manager/ Human Resources Manager. |
| Track cost associated with the EMS. | Finance. |
| Identify customer requirements. | Sales and marketing staff. |
| Compliance with procedures. | All staff. |
| Undertaking audits. | Audit team. |

By determining key on-site issues, it is possible to identify the required roles and responsibilities to ensure effective control. Important areas where responsibilities should be defined are:

- Environmental management programmes (action plans).
- Legislative requirements.
- Control of significant environmental impacts.
- Current responsibilities for environmental management or other management systems (e.g. quality).

## Environmental policy

After significant aspects have been identified, an environmental policy statement can be written. The purpose of a policy statement is to document the environmental intentions and principles of an organisation and to provide a framework for setting objectives and targets. An environmental policy statement is usually of about one page in length and forms a useful marketing tool for the organisation.

Senior management commitment should be clearly identified by the most senior person in the organisation signing the policy.

ISO 14001 states the following principles that a policy must comply with; it must:

ISO 14001 states the following principles that a policy must comply with; it must:

- Be appropriate to the purpose and context of the organisation such as the nature, scale and environmental impacts of its activities, products or services.
- Include a commitment to continual improvement and to the protection of the environment (including prevention of pollution and other relevant specific commitments).
- Include a commitment to fulfill its compliance obligations (both legal and other requirements).
- Provide the framework for setting environmental objectives - the policy must identify general aims on how the organisation is to improve; these are backed up by more specific objectives.
- Be documented, communicated within the organisation and available to interested parties.

## PLANNING

## Actions to Address Risks and Opportunities

### General

Processes to establish, implement and maintain must be developed to meet the requirements of the planning section of the standard. Whilst planning the organisation must consider numerous factors such as context of the organisation, the needs and expectations of interested parties and the scope of the system. It also requires that organisations determine the risk and opportunities related to its environmental aspects, compliance obligations and other issues. The scope of the EMS must include potential emergency situations.

Documented information must be maintained stating organisations risk and opportunities that are required to be addressed in addition to the processes needed to ensure that the requirements of the general section are met as planned.

### Environmental Aspects

The organisation must determine aspects and impacts that it can control and influence. This is a key part of ISO 14001.

ISO 14001 states that identification of environmental aspects should be carried out for activities, products or services that can be controlled by an organisation, or the activities, products or services that an organisation is expected to have reasonable influence over. It allows identification of aspects that have a significant environmental impact.

ISO 14001:2015 states that a life cycle perspective should be considered when determining environmental aspects and impacts. This means identification of aspects and impacts from the cradle to the grave (from the development of raw materials all the way to the final disposal of the product). We will cover this concept in more detail later in the element.

The way in which significant aspects are identified and assessed must be documented. This details responsibilities and arrangements for identifying aspects, determining significance and periodically updating the information.

### TOPIC FOCUS

Various criteria are considered to determine '**significant**' impacts during normal, abnormal and emergency operating conditions:

- Scale, severity and duration of the impact.
- Likelihood of the event occurring.
- Sensitivity of the receiving medium, e.g. presence of protected species or an already heavily polluted watercourse.
- Risk of prosecution.
- Cost of avoiding the impact.
- Cost of any clean-up.
- Adverse reaction of the local community and effect on public image.

### Compliance Obligations

An organisation is required is required to have access to documented compliance obligations related to its environmental aspects and determine how these apply. They must also take into account compliance obligations when developing, maintaining and continually improving the EMS.

## GLOSSARY

### COMPLIANCE OBLIGATIONS

These are legal requirements that and organisation must comply with or another requirement that an organisation has chosen to or must comply.

## Planning Action

An organisation must plan to take action to address its significant aspects, compliance obligations and risk and opportunities. It must also plan to integrate the actions into its EMS processes. Technological, financial and business requirements should be considered in planning.

## Environmental Objectives

To ensure that the commitments stated in the policy are met, objectives need to be developed. Objectives change the nature of the EMS from identifying areas of concern (aspects and impacts) to improving them.

An important part of an EMS is the commitment to and attainment of continual improvement. It is the objectives that help provide evidence for this improvement.

ISO 14001:2015 is vague as to the types of objectives that must be set. There is just a requirement to set objectives and no mention is made as to specific mandatory requirements.

## GLOSSARY

### OBJECTIVE

Result to be achieved. An objective may be strategic, operational or tactical. It may apply to different disciplines and different levels. An objective may be expressed in other ways such as an intended outcome, as an environmental objective or by use of other words (aim, goal or target).

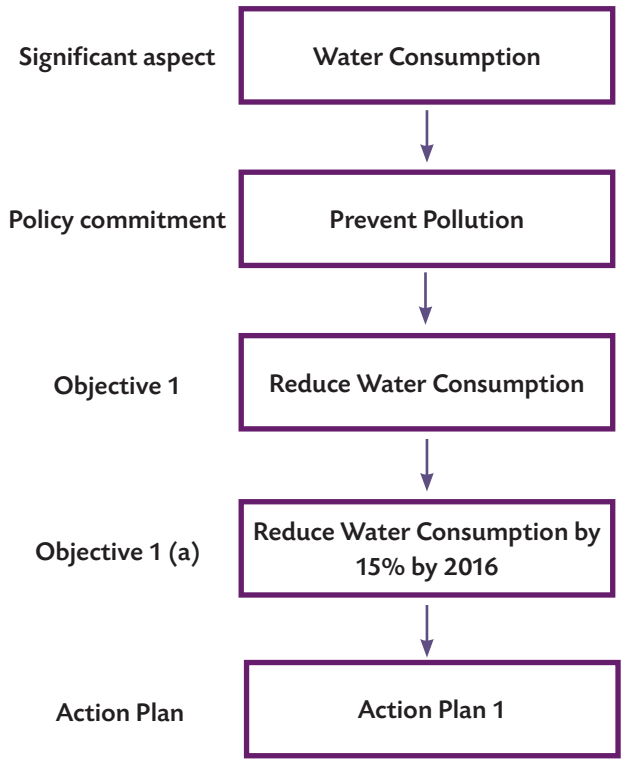
One method however is that organisations initially develop high level environmental objectives which are broad areas of improvement that are normally not quantified. Lower level objectives (sometimes known as targets) are more detailed and are linked to higher level objectives. Usually such lower level objectives are SMART:

- **S**pecific.
- **M**easurable.
- **A**chievable.
- **R**ealistic.
- **T**ime-bound.

Action plans tend to be very low level objectives they identify how the requirements of the linked higher level objectives will be met. As a minimum they tend to consider:

- **Tasks** - to be completed to meet a linked objective
- **Timescale** - by when a task will be completed.
- **Responsibility** - who will be responsible for ensuring that the task is completed.

In practice, they are often limited to addressing significant aspects but they may consider other issues for business or financial reasons.




Environmental objectives example

Organisations will often develop **environmental performance indicators** (a form of key performance indicator) that measure reductions in significant environmental impacts. These are routinely used internally to measure performance but can be externally validated.

## Methods of Selection of Objectives

There is no fixed way of selecting areas where objectives should be set. Determining the type of objective will involve carefully balancing:

- the extent that an impact is an issue to a stakeholder,
- the influence of the stakeholders,
- how well the impact is already being managed, and
- the resources available.

For many organisations the need for improvement is based on what the law requires. In such situations, what the law requires may be the maximum that the organisation can cope with.

# The Key Features and Appropriate Content of an Effective EMS

The ISO 14001 standard states that environmental objectives must be documented and be:

- Consistent with the environmental policy.
- Measurable (the standard states if practicable).
- Monitored.
- Communicated.
- Updated as appropriate.

Whichever method is used to set objectives the ISO 14001 standard states that when planning objectives an organisations must determine:

- What needs to be done.
- What resources will be needed.
- Who will hold responsibility for the objective.
- When the objective is due for completion
- How results will be evaluated.

## SUPPORT

### Recources

The organisation must understand and provide the resources required for the implementation, maintenance and continual improvement of the EMS.

### Competence

Various requirements for competence are present in this part of the standard such as:

- Understand the required competence of those who work could affect environmental performance or compliance obligations.
- Ensure that such person are competent (education, training or experience)
- Understand training needs associated with the environmental aspects and EMS.
- Take action to gain necessary competence and evaluate such actions.
- Documented information as evidence of competence must be retained.

## GLOSSARY

**COMPETENCE**

Ability to apply knowledge and skills to achieve intended results.

### Awareness

Those who carry out work under the organisations control must be aware of the environmental policy, significant environmental aspects and impacts, their contribution to the effectiveness of the EMS and implications of not complying with the EMS.

### Communication

Having effective communication structures is important to:

- Motivate the workforce.
- Explain the environmental policy (both internally and externally) and how it relates to the overall vision/ strategy of the organisation.
- Ensure understanding of roles and responsibilities.
- Demonstrate management commitment.
- Monitor performance.
- Identify potential system improvements.

ISO 14001 requires that an organisation has processes that covers:

- Internal communications between the various levels and functions of the organisation.
- External communication of information relevant to EMS as stated in the organisations.
- Communication process and required by compliance obligations.

Such processes need to cover:

- What will be communicated.
- When to communicate.
- With whom to communicate with and the methods of communication.

The organisation must also consider processes for external communication on its significant environmental aspects and record its decisions.

### Documented information

Specific requirements are present in the standard for various information to be documented in addition to information deemed to be necessary for the EMS by the organisation. There are also document information requirements for:

- Creating and updating: documented information should be able to be identified (e.g. date title reference number), a correct format should be used (language, software version etc) and reviewed and approved for suitability and adequacy.
- Document Control: documents must be controlled to ensure availability, adequate protection (loss of integrity). More specifically an organisation must consider distribution, storage, preservation, control of changes and retention.

## OPERATION

Certain activities and operations must be controlled within the EMS. The standard states that controls can be both procedural and engineering and may follow a hierarchy of elimination, substitution and administrative.

Consistent with a life cycle perspective the organisation must:

- Develop controls to ensure environmental requirements are considered at each life cycle stage during the development process of products and services.
- Determine what requirements are needed for the procurement of products and services.
- Communicate relevant environmentally related information to external providers (e.g. contractors)
- Consider whether to provide information regarding significant impacts associated with transport, delivery, end of life treatment and end of life disposal of products and services.

Significant aspects should be controlled. This would be carried out by considering the activities that cause these aspects and what type of control is required to manage or minimise impacts. A draft procedure could then be developed, which should be trialed and amended as required, prior to issuing of the final version.

### Emergency Preparedness and Response

Organisations must develop and maintain documented processes to identify and respond to accidents and emergencies and to **prevent or reduce environmental impacts** that are associated with them. The processes must be reviewed and revised on a regular basis, particularly after an accident has occurred. They must also be tested.

Common accidents that have an environmental impact include:

- Fires.
- Floods.
- Waste water releases.
- Air releases.

The number and type of procedures that are required to be developed depend on the type and complexity of an organisation; e.g. a large chemical company will need a relatively complex emergency plan, whereas an office would require a few simple procedures.

## TOPIC FOCUS

**Emergency preparedness and response plans** may include the following elements:

- On-site emergency response teams and equipment.
- Key personnel duties, responsibilities and contact details.
- Interrelationship with, and contact details for, off-site emergency services.
- Internal and external communication plans.
- Training arrangements and practice drills.
- Detailed response measures for each type of emergency incident - including personnel response and equipment needs.
- Inventories, locations, method of storage and potential effects on the environment of the full range of chemicals held on the site.

## PERFORMANCE EVALUATION

### Scope and Purpose of Auditing Environmental Management Systems

## GLOSSARY

### ENVIRONMENTAL AUDIT

"systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which the audit criteria are fulfilled"

ISO 14001: 2015

An audit will usually only look at a sample of the processes and activities that are taking place within an organisation and the documentation controlling them. It is therefore essential that the process is carried out in a systematic way. This helps ensure that the results of the audit are objective and that different auditors achieve similar results. Objective results are based on evidence, not hearsay, so it is essential that an auditor follows a trail of evidence to a final conclusion. For example, if, on inspecting emissions-testing results, the first is found to be over a prescribed limit but the auditor is told this is exceptional and unusual, he must look further at other results to ascertain for himself whether this is the case or not.

The audit criteria must be defined before the audit process starts, as these are the terms against which the audit will be judged. For example, an EMS audit being undertaken with a view to gaining certification to the **ISO 14001** standard will be to confirm whether or not the organisation's EMS conforms to the requirements of the **ISO 14001** standard.

The scope of the audit will be defined by the scope of the EMS, as this is what is being audited; the purpose will be to identify that the EMS complies with the standard.

## Distinction Between Audits and Inspections

There is often confusion between inspections and audits and it is important to understand the differences between them.

- Inspections are an assessment of what is there at the time an inspection takes place. They are essentially looking for signs of failure, e.g. leaks in pipes, broken lights, signs of damage, etc.
- Audits are a pre-planned, systematic and objective assessment of a situation against a given set of criteria. For example, clause 5.2 of **ISO 14001:2015** states:

  *"Top management shall establish, implement and maintain an environmental policy that, within the defined scope of its environmental management system is appropriate to the purpose and context of the organisation."*

The auditor would be looking for evidence to establish that a policy is in place, has been agreed to by top management and is appropriate to the nature and scale of the organisation.

## Internal Audit

**ISO 14001** states that audit programmes should cover:

- The activities and areas to be considered in audits.
- The frequency of audits.
- The responsibilities associated with managing and conducting audits.
- The communication of audit results.
- Auditor competence.
- How audits are to be conducted.

The organisation must define audit criteria for each audit, select auditors for and objective and impartial and ensure that results are communicated to management. Documented evidence of the implementation of the audit programme must be retained.

The scope of an EMS audit is vast, but it basically seeks to determine whether the EMS conforms to **ISO 14001**, legal issues and procedures. It should also provide information to show if the EMS is properly implemented and maintained. The audit report is required to provide information to management on the results of audits.

The internal audit plays an important role within the EMS and therefore is an important component of the certification assessment.

Internal audits of the EMS are often performed by personnel from within the organisation, although external auditors may be used. In any event, persons conducting the audit should be competent and have no responsibility for the activity being audited.

## Environmental Auditing

### Pre-Audit Preparations

Before an audit takes place, some preparation is required by both the audit team and the auditee (the person or organisation being audited):

- The scope of the audit must be defined, e.g. a specific factory or office location, or a production process and the EMS surrounding that process.
- There may be logistical issues to arrange, such as:
  - transport around a large site;
  - correct Personal Protective Equipment (PPE);
  - sufficient employees to accompany the auditors;
  - office space, both for the auditors to work in and for opening and closing meetings.

### Information-Gathering

An essential starting point in any audit process is the gathering of existing information that will inform the direction and focus of the audit. This will help ensure that the auditor is as familiar as possible with the organisation's activities and highlight particular areas or questions that the auditor needs to focus on. Much of the information-gathering will be based on a review of documentation (see Topic Focus), especially:

- Site plans.
- The results of previous audits.
- Records of emissions monitoring (versus legal limits).
- Accident/incident reports.
- Enforcement notices.

### Notifications and Interviews

Key personnel must be informed if they are to be involved in the audit, as it is important that they are available and they may have their own preparation to complete before the audit. Interviews should be conducted in a reasonably formal manner without being confrontational. Many people feel uncomfortable being interviewed and tend to say as little as possible. The skill of the interviewer is in getting them to talk openly. This helps ensure that both positive and negative issues are aired and the evidence can be identified so that improvements can be made.

## Responsibility for Audits

Ultimate responsibility for ensuring that auditing is carried out will rest with senior management. Internal audits should normally be carried out by those with no line-management responsibilities for the specific activities being audited. A team approach is often used, consisting of managers as well as workers. The key thing is that the auditors are competent and responsible. External audits will be required for **ISO 14001** certification.

## Advantages and Disadvantages of External and Internal Audits

There are advantages and disadvantages to both internal audits (First-Party Audits) and external audits (Second- and Third-Party Audits).

### GLOSSARY

**FIRST-PARTY AUDIT**

Often referred to as an internal audit; usually undertaken by the organisation's own auditors.

**SECOND-PARTY AUDIT**

Undertaken by another organisation, often a consultancy, or a team of auditors from another organisation.

**THIRD-PARTY AUDIT**

An independent, formal audit; usually undertaken by an accredited certification body.

| | Internal Audit | External Audit |
|---|---|---|
| **Advantages** | • Reduced costs.<br>• Auditor probably has better understanding of the business.<br>• Interviewees may relax more with someone they know, or who at least is from within the organisation.<br>• More flexibility on times for audits and potential to change if needed. | • Objective auditor with no preconceived perceptions.<br>• Auditor likely to have experience of other similar processes/ industries, so able to bring a comparative view.<br>• Seen by external parties (customers, suppliers and regulators) as more objective and carries more weight.<br>• Once audit is booked, it is a set deadline by which to achieve objectives.<br>• Auditor less likely to be unduly influenced by senior managers not to highlight poor areas. |
| **Disadvantages** | • Auditor may be "blind" to some problems, as they are "situation normal".<br>• Seen by external parties (customers, suppliers, etc.) as less objective.<br>• Auditor possibly more open to pressure from senior management not to highlight negative points.<br>• Flexibility may lead to audits continually being put off.<br>• Time required for employees to conduct audits and also attend training. | • Costs increased.<br>• Less flexibility on times; once audit is booked it is likely to be charged for, so greater pressure to undertake even if not quite ready.<br>• Auditor may not fully understand some of the issues involved.<br>• Interviewees may not feel they want to discuss problem areas with an external person. |

## Monitoring, Measurement, Analysis and Evaluation

An organisation environmental performance must be monitored, measured, analysed and evaluated. An organisation must determine:

- What should be monitored and measured
- The methods for monitoring, measuring, analyzing and evaluating.
- What criteria the organisation performance is compared against
- The frequency of monitoring.
- When monitoring results should be analysed and evaluated.

The organisation is also required to communicate performance both internally and externally (should be identified in communication process). Documented of evidence of monitoring must be kept.

Processes must be developed, implemented and maintained to demonstrate that the organisation has fulfilled its compliance obligations.

Such an evaluation processes must include the frequency of compliance evaluation, any action required and maintenance of knowledge and understanding of organisational compliance status.

Documented evidence of the evaluation of compliance must be retained by the organisation.

## ACTIVE MONITORING MEASURES

"Active" (sometimes called "proactive") simply means measuring progress towards targets before anything has gone wrong and possibly looking for trends that identify potential problems in the future.

### TOPIC FOCUS

**Active monitoring measures** could include:

- Emissions – monitoring atmospheric or water emissions (and comparison with permit conditions).
- Effluent – measuring the flow rate of a discharge to water.
- Waste – monitoring production of waste over time.
- Energy and water – monitoring use over time can provide valuable information on the efficiency of machinery and the presence of leaks for water.
- Mass balance calculations (measuring materials in and out of a process, checking for leaks).
- Key Performance Indicators (KPIs) (see below) for all relevant parties, such as senior managers, procurement department, and suppliers involved in the environmental management of the organisation.
- Site inspections and tours.

## Use of Environmental Inspections and Tours

Inspections and tours can be used as tools to gather evidence of environmental performance. An environmental inspection should:

- Be a formal, organised walk-round of a workplace, or section of a workplace.
- Identify uncontrolled environmental impacts and non-compliances.
- Ensure that suitable controls are put in place.

A checklist is typically used. Minor defects may be rectified at the time but others may need finance and other resources to resolve them.

Inspections can be grouped into three main types:

- General environmental inspections – undertaken by managers, environmental representatives, or other suitably trained members of staff.
- Statutory inspections – required by legislation.
- Compliance inspections:
  - To compare against stated performance standards, which may include legal compliance and may also form part of an audit.
  - Undertaken by staff from an internal control department, or by an enforcement agency.

A tour, as opposed to an inspection:

- Usually follows a predetermined route through the area or workshop.
- Typically lasts only 15 minutes or so.
- May be conducted at weekly intervals to ensure that standards are maintained.

## Factors Governing Frequency

The frequency of the inspections will depend on issues such as:

- The purpose of the inspection.
- Any frequency imposed by regulations, such as discharge consent or environmental permits.
- The level of risk to the environment.
- Conditions found at the last inspection.

### GLOSSARY

**KEY PERFORMANCE INDICATORS (KPIS)**

Help define and measure performance towards an objective. They are a key part of a measurable objective. Example KPIs could include emission of greenhouse gases or metal emissions to water. To be measurable the target would need to be quantified.

## Competence of Inspector

It is important that the person carrying out the inspection is competent to do so and, in some cases, it may be necessary for several people to carry out the inspection together to cover all the areas of expertise required. For example, in a large production process, such as cement manufacture, it may be necessary for a production manager or supervisor to be accompanied by the environmental manager, as one is likely to understand the process in depth and the other will have greater understanding of the legal obligations imposed by an environmental permit.

Anyone carrying out an environmental inspection should have as a minimum:

- An understanding of the tools of workplace inspections, their advantages and disadvantages, and how to use them.
- An understanding of the process or activity being inspected.
- Knowledge of the potential environmental impacts from the process or activity.
- Knowledge of the standards that are acceptable.
- A basic report-writing ability, or ability to use a checklist.

## Use of Checklists

Preparing a checklist will contribute to the success of an inspection.

A checklist:

- Provides a reference point to ensure the inspection remains focused.
- Can be deviated from, e.g. to investigate an unexpected problem or defect, but provides a "bookmark" for the inspector to continue the inspection from where he/she left off.
- Aids note-taking and provides an easy way to follow up on issues found during an inspection that could not be followed up immediately.

There is no set format for a checklist, as this will vary with the activity being inspected and the individual preference of the inspector.

### TOPIC FOCUS

Examples of the areas that may be covered in a general **checklist** include:

- Site drainage – marked with type of drain and direction of flow.
- Fugitive emissions – unplanned emissions.
- Waste – correct type of containers, correct waste in containers, segregated and secure.
- Discharges from interceptors – visible signs of oil.
- Noise – unusual noise levels.
- Signs – are they clear and correct?
- Signs of leaks from machinery or other spills.
- Are unattended machines left running?

## Allocation of Responsibilities

Some faults will need specialist knowledge to resolve and others will require the allocation of finance and resources. Responsibilities for corrective and preventative actions will therefore need to be allocated.

## Priorities for Action

Priorities for dealing with the issues identified will need to be set. These priorities should be based on the level of risk to the environment, even though some of the actions will take longer to complete owing to the level of resources required. Issues affecting legal compliance must be allocated a high priority, as these are likely to not only have significant environmental impact but also a significant impact on the business should enforcement action be taken.

## REACTIVE MONITORING MEASURES

Reactive monitoring is effectively the monitoring of organisational failures with a view to preventing a recurrence of the failure. So, it is a reaction to an undesirable event that has already occurred. Lessons need to be learned and both corrective and preventative actions taken. "Reactive monitoring measures" are simply data arising from these reactive monitoring techniques.

## TOPIC FOCUS

**Reactive monitoring measures** could include:

- **Near-misses** – unplanned, unwanted events that have the potential to cause environmental damage. Oil getting into a drain system, for instance, but being caught before it reaches controlled waters, would be a near-miss.
- **Complaints** from neighbours and/or the workforce – often an early sign that something has changed in the process, creating a potential problem. This may be noise, dust, odour, etc.
- **Emissions monitoring** – e.g. from chimney stacks or effluent discharges. This will identify any unplanned excessive emissions possibly due to plant failure or a change in process.
- **Waste-stream monitoring** – the quantity and type of waste produced. Increases in waste going to final disposal, for example, may indicate a deterioration in waste management control.
- **Energy** – measuring energy usage in different buildings or different parts of a building will identify areas of excessive energy use.
- **Water** – recording water usage will identify trends in water consumption.
- **Enforcement action** – a major signal that things are not right. Enforcement action shows that not only are there potential deficiencies within the main process but also with the way active monitoring is carried out, or the way the results of that active monitoring are dealt with.

## REVIEW OF ENVIRONMENTAL PERFROMANCE

The purpose of reviewing environmental performance is to analyse the data gathered through the monitoring techniques discussed above and to make decisions on whether that performance is acceptable. The review can then question whether the organisation:

- Is achieving its environmental objectives.
- Is implementing effective environmental controls.
- Is being effective in its training, communication and consultation with employees and other stakeholders.
- Learns lessons from environmental incidents and implements effective corrective and preventative actions.
- Is legally compliant.
- Reduces the risk of causing environmental damage.

Identifying strengths and weaknesses, and highlighting where standards have dropped or changes have occurred, will allow the review process to maintain the momentum in the EMS and to continually improve and manage change.

## Gathering Information to Review Environmental Performance

## TOPIC FOCUS

Various **sources of information** can be used to provide data for both the initial and the management environmental review:

- Incident data – often provides information on effectiveness of procedures and training currently in place. Although a failure has occurred, there is an opportunity to learn from it and improve in the future.
- Inspections – opportunities to identify potential incidents before they occur and rectify problems early.
- Control and monitoring of emissions – ensures compliance with any legal requirements on emission levels and allows trends to be analysed to identify any potential future problems.
- Energy/raw material management – changes in volumes of raw materials and energy per unit of production may be an early indication of failures developing in the system.
- Waste management – increases in waste generated per unit of production act in a similar way to energy and raw materials.
- Surveys, tours and sampling – as for inspections.
- Quality assurance reports – provide similar data to raw materials and energy usage and waste produced. Together they will provide an indication of changes in the process.
- Audits – highlight areas for improvements in either the procedures or the implementation of those procedures.
- Monitoring data/records/reports – as for inspections and control and monitoring of emissions; will usually support the findings of inspections, audits, etc.
- Complaints – a valuable independent source of data that can lead to indications of improvements required in the processes, or the procedures for monitoring.

## Investigating Environmental Incidents and Reporting Requirements Internally and Externally

Environmental incidents would normally be reported internally (within the organisation) and may also need to be reported externally (e.g. to enforcement agencies and insurance companies). Management may investigate environmental incidents, or at least take an active interest in the findings of investigation reports, and these may all contribute to the management review.

## Reporting on Environmental Performance

Review findings can also be incorporated into environmental performance reports, both internally and externally to, for example, shareholders and other stakeholders.

## Role of Boards, Chief Executive/ Managing Director and Senior Managers

Selected members of the senior management team should perform the periodic review. This ensures Board involvement, giving the necessary authority and weight to the process.

## Feeding into Action and Development Plans as Part of Continuous Improvement

Each periodic review should naturally output decisions and actions needed for improvement of the EMS. If successfully implemented, this should lead to continual improvement over time.

## GLOSSARY

### MONITORING

Methods used by an organisation to measure how effectively policies are being implemented, how well they are controlling environmental risks and how the culture of the organisation is developing with regard to environmental protection.

### REVIEW

Analysis of the data gathered through the monitoring processes, allowing an organisation to judge whether environmental risks are adequately controlled.

### AUDIT

An objective and systematic assessment of the organisation's EMS in order to determine if systems exist, are adequate, and are used.

## Management Review

The **ISO 14001** standard identifies that an organisation's top management must review the EMS to ensure that it is suitable, adequate and effective. The review should also be completed at specified intervals. The management review must be developed to assess the needs for EMS improvements. Review frequency is not identified in **ISO 14001**; however, most organisations undertake a management review on an annual basis.

The standard states that the management review must include:

- Status of actions from previous reviews.
- Changes in significant aspects.
- Internal and external issues.
- The extent to which objectives have be reached.
- Information on the environmental performance of the organisation such as trends in monitoring results, fulfilment of compliance obligations and audit results.
- How adequate resources are used.
- Communications form interested parties (this includes complaints).
- Areas where there are opportunities for continual improvement.

The output of the management review will include:

- Whether the EMS is still suitable, adequate and effective.
- Decisions that are linked to continual improvement.
- Action when environmental objectives have not been met.
- Areas where the EMS could be integrated with other business processes.
- Implication for the strategic direction of the organisation.

**Documented evidence of the results of the management review must be kept.**

## IMPROVEMENT

An organisation must determine where improvement opportunities exist and implement actions to ensure achievement of EMS outcomes.

## Nonconformity

If a nonconformity occurs organisations must take necessary action to ensure that it is controlled and rectified. It must also react to the consequences of the nonconformity such as mitigating the adverse environmental impacts that may occur.

Action is also required to eliminate the cause of the nonconformity to ensure that it does not happen again. This is to be achieved by undertaking a review of the nonconformity, understanding the causes and to determine whether a similar nonconformity exists or could occur. Any corrective action implemented must be reviewed for its effectiveness.

Documentary evidence must be retained as to the nature of nonconformities, action undertaken to correct them and the results of the corrective actions

## GLOSSARY

### CONFORMITY

Fulfillment of a requirement.

### NONCONFORMITY

Non fulfillment of a requirement.

### Continual improvement

The organisation is required to ensure continual improvement of the EMS's suitability, adequacy and effectiveness to enhance environmental performance.

## GLOSSARY

### CONTINUAL IMPROVEMENT

Recurring activity to enhance performance. Enhancing performance is related to the use of the EMS to improve environmental performance consistent with the environmental policy.

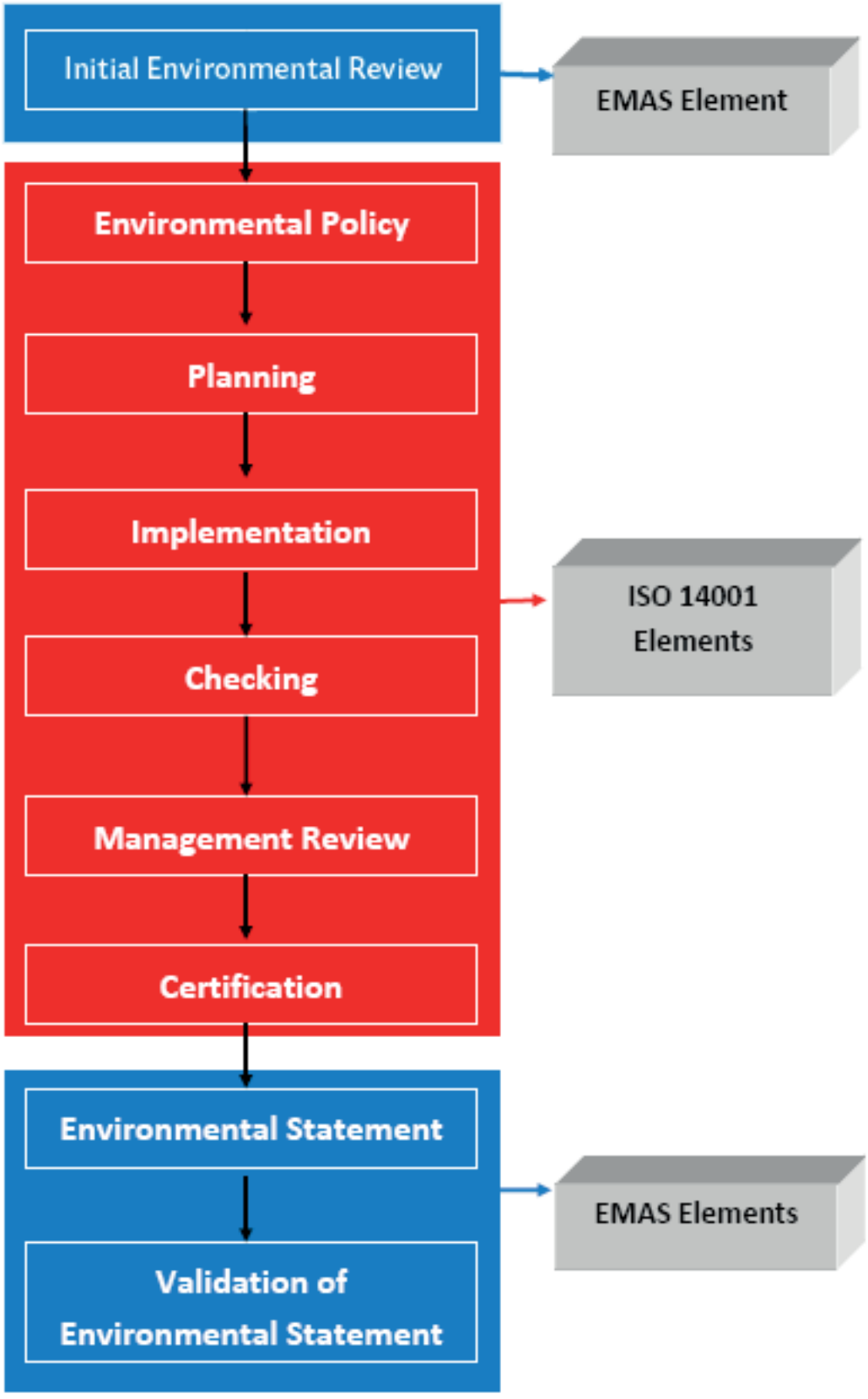
## ECO-MANAGEMENT AND AUDIT SCHEME (EMAS)

In addition to the international EMS standard **ISO 14001**, a European-based standard – the **Eco-Management and Audit Scheme** (EMAS) – has been developed (under **Regulation 1221/2009**). EMAS is a European regulation that enables industries to voluntarily implement formal environmental management systems.

EMAS shares a common core framework with **ISO 14001** and so provides an organisation with a structured approach for identifying, evaluating, managing and improving its environmental performance. Although similar in content, EMAS has a number of important differences from **ISO 14001**. These include:

- A formal environmental review must be documented as a precursor to establishing the system.
- An independently verified Environmental Statement must be prepared, which sets out key information for the public about the organisation's impacts and actions.
- An open dialogue must be established with the public and other interested parties.
- EMAS uses stronger and more specific language about legal compliance than **ISO 14001**. Breaches of legislation may result in EMAS registration being withdrawn.

The key difference between EMAS and **ISO 14001**, however, is that EMAS is a European, rather than international standard. This means that there are fewer than 5,000 EMAS registrations worldwide – mostly held by larger industrial companies, to which EMAS is best suited.



## REVISION QUESTIONS

2. What is an environmental policy?
3. List the seven key stages within an **ISO 14001** Management System Process.
4. Who should prepare and endorse the environmental policy?
5. List any three of the main inputs into a management review of an environmental management system.
6. What factors should be considered when deciding how frequently environmental inspections should be held?
7. What should be the minimum requirements for someone carrying out an environmental inspection?
8. Explain the difference between an environmental audit and an environmental inspection.

(Suggested Answers are at the end.)

# Benefits and Limitations of Introducing Formal EMS into the Workplace

## KEY INFORMATION

- There are benefits associated with introducing **ISO 14001/BS 8555** into the workplace.
- There are also limitations when introducing **ISO 14001/BS 8555** into the workplace.

## BENEFITS OF INTRODUCING ISO 14001 INTO AN ORGANISATION

Many people argue that introducing and operating an EMS in an organisation is free of charge. This is not to say that there are no costs involved, but that the benefits gained from the implementation and operation of an EMS far outweigh those costs and therefore there is a net benefit. It is clear that there are many benefits associated with the implementation of an EMS and certification to the 14001 standard.

## TOPIC FOCUS

**Benefits of Introducing ISO 14001**

- Increased compliance with legislative requirements:
  - An organisation must identify relevant compliance obligations such as legislation, and this surely is the first step to compliance.
  - Written procedures are in place so that employees understand how they can comply with the legislation.
  - The profile of legislation is raised within the management team and highlights the potential penalties for non-compliance.
  - Where procedures are written in such a manner as to ensure activities are carried out in compliance with legislation, compliance is more likely to be assured.
- Competitive edge over non-certified businesses.

  Many organisations now require suppliers to provide evidence of their commitment to improving their environmental performance and reducing their impact on the environment. A certified management system is excellent evidence for this and, in many cases (such as many local government contracts), it is a prerequisite for tendering.
- Improved management of environmental risk.

  The compilation of the Aspects and Impacts Register ensures that the significant impacts are identified and, once identified, they are more likely to be controlled sufficiently to prevent unauthorised pollution incidents from occurring.
- Increased credibility that comes from independent assessment.

  While it is not a requirement of the standard to undergo external certification, there are significant advantages, as the organisation potentially gains considerably increased credibility in the market place.
- Savings from reduced non-compliance with environmental regulations.
  - There may be reduced costs for permits where there is better environmental performance.
  - The risk of incurring costs, such as fines and penalties for non-compliance, is reduced.

(Continued)

## TOPIC FOCUS

- Heightened employee, shareholder and supply-chain satisfaction and morale.

  Investors and employees want to be associated with positive environmental images.
- Meeting modern environmental ethics.

  The ethical investment market is growing steadily - from a niche marketplace a few years ago to now being a mainstream opportunity.
- Streamlining and reducing environmental assessments and audits.
  - Integration of quality, health and safety and environmental management systems can result in more streamlined assessments and audits.
  - Audits will be more systematic and planned (instead of haphazard) and demonstrate continual improvement.
- Increased resource productivity.

  It has been shown that those companies with certified management systems are also some of the best performing companies in the marketplace, as these are also the better managed companies.

## LIMITATIONS OF INTRODUCING ISO 14001 INTO AN ORGANISATION

While there are many benefits, as discussed above, to implementing a management system certified to the **ISO 14001** standard, it is not without some limitations.

## TOPIC FOCUS

**Limitations of Introducing ISO 14001**

- Prescriptive environmental performance levels are not included within the standard.

  Organisations must set what they consider to be relevant performance levels and it is not easy to compare one organisation in a particular industry with others in the same industry.
- Improvements in environmental performance can be negligible.
  - For some organisations, especially small, low-impact ones, there may be very little room for them to improve their impact, especially in ways that will also have a significant positive impact on the performance of the company.
  - Some organisations also find that as the system matures, it is difficult to satisfy the requirement to continually improve their performance.
  - This may lead to an organisation focusing on trivial and insignificant issues that have little impact on the environment but consume significant resources in time and money.
- Lack of public reporting, unlike other internationally recognised management systems.

  Unlike the **Eco-Management and Audit Scheme** (EMAS), **ISO 14001** does not require an organisation to publicly report its environmental performance.
- Inconsistency of ISO auditors.

  The 14001 standard can be self-certified but is much more credible if certified by an external body. There is, however, often considerable variation in the approach that individual auditors take towards certifying organisations. This is often dependent upon the individual's knowledge and experience of the particular industry being audited, which could range from chemical works and nuclear power stations to offices and leisure facilities.
- Implementing an EMS may have high cost implications for small and medium–sized enterprises.
  - Implementing an EMS is not cheap.
  - Typically, implementation takes six to eight months and will require the services of an experienced consultant to at least direct progress towards certification.
  - There is also the cost of external certification bodies' initial and re-certification audits and of the more frequent surveillance audits, between certification visits.

## ISO 14000 FAMILY OF STANDARDS

In addition to **ISO 14001**, there are also other useful environmental standards in the 14000 series. These include:

| Standard | Title |
|---|---|
| ISO 14004:2004 | Environmental Management Systems – General Guidelines on Principles, Systems and Support Techniques |
| ISO 14015:2001 | Environmental Management – Environmental Assessment of Sites and Organisations (EASO) |
| ISO 14020:2000 | Environmental Labels and Declarations – General Principles |
| ISO 14021:1999 | Environmental Labels and Declarations – Self-Declared Environmental Claims (Type II Environmental Labelling) |
| ISO 14024:1999 | Environmental Labels and Declarations – Type I Environmental Labelling – Principles and Procedures |
| ISO 14031:2013 | Environmental Management – Environmental Performance Evaluation – Guidelines |
| ISO 14040:2006 | Environmental Management – Life Cycle Assessment – Principles and Framework |
| ISO 14044:2006 | Environmental Management – Life Cycle Assessment – Requirements and Guidelines |
| ISO 14050:2009 | Environmental Management – Vocabulary |
| ISO 14064-1:2006 | Greenhouse Gases – Part 1: Specification with Guidance at the Organisation Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals |
| ISO 14064-2:2006 | Greenhouse Gases – Part 2: Specification with Guidance at the Project Level for Quantification, Monitoring and Reporting of Greenhouse Gas Emission Reductions or Removal Enhancements |
| ISO 14064-3:2006 | Greenhouse Gases – Part 3: Specification with Guidance for the Validation and Verification of Greenhouse Gas Assertions |
| ISO 14005:2010 | Environmental management systems – Guidelines for the Phased Implementation of an Environmental Management System, Including the Use of Environmental Performance Evaluation |

**ISO 19011:2011** *Guidelines for Auditing Management Systems*, although not classed as being in the 14000 series, also includes requirements for EMS auditing.

**Note:** The **ISO 14001:2004** standard was replaced by **ISO 14001:2015** in September 2015. From this date there will be a period of transition to allow organisations to adapt their environmental management systems to meet the requirements of the new standard.

Key changes incorporated into the revised **ISO 14001:2015** standard are as follows:

- The standard follows a new common structure that allows easier integration with other management system standards, such as **ISO 9001** on quality management.
- There is greater focus on improving environmental performance taking account of upstream (e.g. supplier) and downstream (e.g. customer use) areas of a company's 'value chain'.
- A greater emphasis is placed on top management involvement and the integration of environmental management into core business practices.
- There is greater focus on the need to evaluate organisational risks in the context of external environmental conditions (e.g. adapting to climate change, or resource shortages).

### REVISION QUESTION

9. List three benefits and three limitations associated with the implementation of an EMS and certification to the 14001 standard.

(Suggested Answer is at the end.)

## SUMMARY

This element has dealt with the key features, benefits and limitations of environmental management systems.

In particular, this element has:

- Identified some of the main reasons for implementing an Environmental Management System (EMS):
  - It demonstrates senior management commitment to environmental management.
  - **ISO 14001**, **ISO 9001** and **OHSAS 18001** share common management system principles, so the three systems can be integrated into an environmental, health, safety and quality system.
  - It is often required by stakeholders (e.g. customers or regulators).
  - It demonstrates a sense of corporate responsibility.
- Shown how an initial environmental review should cover all current activities and answer the question: "Where are we now?"
- Explained that the environmental policy should:
  - Be appropriate to the nature and scale of the organisation.
  - Include a commitment to continual improvement.
  - Fulfill compliance obligations.
  - Provide a framework for setting and reviewing of objectives.
  - Be communicated to interested parties.
- Described how the organisation's planning should include:
  - Up to date information in relation to, and evaluation procedures to determine, significant actual or potential environmental impacts.
  - Procedures for identifying compliance obligations relating to land and buildings, processes and plant, products and services, and environmental performance standards it should achieve.
  - Establishment of environmental objectives.
  - Environmental management programmes.
- Explained how requirements for operation and performance evaluation of an EMS, are contained within the clauses of **ISO 14001.**
- Outlined the purpose of an environmental audit to establish that an EMS complies with the requirements of **ISO 14001**.
- Described how both active (regular monitoring of performance standards and systematic inspection of plant and processes) and reactive (data on near-misses and complaints) monitoring techniques should be used to collect information on environmental performance.
- Explained that regular reviews of the EMS should be carried out by senior management, with the aim of implementing continual improvement of performance.
- Given examples of the **benefits** that introducing an EMS can include, such as:
  - Increased compliance with legislative requirements.
  - Improved management of environmental risk.
  - Increased resource productivity.
- Shown that there are **limitations** when introducing an EMS, including:
  - Negligible improvements in environmental performance.
  - Inconsistency of ISO auditors.
  - Excessive implementation costs for small and medium-sized enterprises.
- Considered the members of the **ISO 14000** series of environmental standards.


## QUESTION

**Outline** key internal documents that are likely to be reviewed during an environmental audit of a manufacturing facility. (8)

### APPROACHING THE QUESTION

As before, using good exam technique, you must:

- Read the question.
- Consider the marks available. In this case, there are eight marks available so you should spend around nine minutes answering the question and provide eight pieces of significantly different information.
- Highlight the key words. In this case the key words would include 'outline', 'internal documents', 'audit', 'manufacturing facility'.
- Read the question again.
- Jot down an outline plan – this might include:
  - Results of past audits, monitoring, complaints records, accident reports, EMS, maintenance, proactive monitoring, staff training records.

With this question you need to determine what type of document would be viewed during an audit of a manufacturing facility. 'Manufacturing facility' is quite a broad scenario, so you can use your imagination as to what is actually manufactured.

### SUGGESTED ANSWER

Now you have finished your answer, read the suggested answer below and compare it to your answer.

An internal document that is likely to be reviewed is the result of previous audits. These will identify weaknesses in management and identify areas that may need to be considered in the current audit.

Records of monitoring of air emissions, raw-material usage and energy consumption would all need to be considered. Such documents will highlight the level of compliance with emission limits in permits, consents or other documents.

Complaint records will also give the auditor an idea of the significant impacts that have occurred and the corrective actions implemented; they may also need to be retained for legal reasons (e.g. requirement of an installation permit).

Any reports from past accidents or incidents would also need to be considered, as they will, again, highlight deficiencies in the management of the company's environmental impacts.

The company's environmental policy, procedures, processes and EMS manual are also likely to be inspected, as these will show the robustness of the management system that the company operates.

Additionally, maintenance logs could be considered in order to check the level of maintenance of key pollution abatement equipment, such as secondary containment for tanks, or air-pollution abatement devices.

The results of proactive monitoring, such as site inspection could also be considered, as these will form part of the management system of the organisation.

Staff training records will also be considered for staff who could cause a significant environmental impact. Training is important, as it may be an important risk-control measure for the organisation.

# ENVIRONMENTAL IMPACT ASSESSMENTS

ELEMENT 3

## LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Explain the reasons for carrying out environmental impact assessments.
2. Describe the types of environmental impact.
3. Outline the human factors which influence behaviour at work in a way that can affect health and safety.
4. Identify the nature and key sources of environmental information.
5. Explain the principles and practice of impact assessment.

# Contents

# Reasons for Carrying Out Environmental Impact Assessments

## KEY INFORMATION

- An Environmental Impact Assessment is a tool used to identify environmental impacts, to assess the level of risk from those impacts, and to develop and implement appropriate controls (or mitigation) to reduce the environmental risk.
- Life-Cycle Analysis is a tool used to identify and measure the environmental impact of a product or service throughout its life cycle – a 'cradle-to-grave' approach.

Before any organisation can start to develop an environmental improvement programme it needs to answer the question: "What environmental impacts do we have?" If you don't know what the problems are, you can't fix them!

There are various tools and techniques that organisations can use to identify and characterise the environmental issues associated with their activities. This needs to be done systematically to ensure that:

- nothing significant is omitted; and
- managing the most important issues is given priority.

### AIMS AND OBJECTIVES OF IMPACT ASSESSMENT

Environmental impact assessments may be used to identify environmental impacts from any activity or site, regardless of their size or nature. The objectives are to:

- Identify beneficial and negative environmental impacts of an activity.
- Suggest mitigation or control measures to prevent or reduce negative impacts.
- Identify appropriate strategies to monitor impacts and provide an early warning of any adverse changes.
- Incorporate environmental information into the decision-making process relating to development projects.
- Aid selection of the best option if alternatives are available.

## EU Environmental Impact Assessment Directive (2011/92/EU)

It should be noted that the term Environmental Impact Assessment (EIA) has a special meaning when used in the context of the EU EIA Directive. This Directive requires formal, documented impact assessments of development projects likely to have significant environmental effects, prior to them being granted planning consent by local and/or national authorities. An environmental impact assessment must be carried out on the environmental effects of proposed major industrial or civil engineering developments, as specified in Schedule 1 of the Regulations – including, for example: crude-oil refineries, major power stations, iron and steel plants, chemical plants and major roads, railway lines and ports.

EIAs that meet the requirements of the Directive for planning purposes must follow a defined process:

Process and Stages of Environmental Impact Assessment

| | |
|---|---|
| **1. Screening** | This stage is a formal decision about whether the development requires an EIA or not. |
| **2. Scoping** | Decide which environmental impacts are to be considered in detail. This will depend on the type of development, for example:<br>• Air emissions?<br>• Noise emissions?<br>• Discharges to water? |
| **3. Baseline Studies** | For the impacts selected above: determine the current status. For example, what is the current air or water quality like? |
| **4. Impact Assessment Significance** | Consider whether your proposed or existing development will have a significant impact. For example, will your development cause the air quality to deteriorate significantly? |
| **5. Mitigation** | If there will be a significant impact, what can you do to reduce it? For example, can you fit abatement technology to control air emissions, or not operate at night to prevent noise nuisance to residents? |
| **6. Application and Environmental Statement** | Development of an environmental statement (different terminology may be used, but this is essentially a report) to document the EIA. |
| **7. Monitoring** | All developments or existing industries will need to monitor their significant impacts to ensure mitigation measures remain effective. |

Let's look now at how we characterise environmental issues, and some key tools for identifying impacts.

## Meaning of Aspects and Impacts

The photograph shows a coal-fired power station. We can see that the chimneys are emitting smoke and fumes into the surrounding air. This is clearly one way in which the facility is interacting with the environment – we call this an environmental aspect.

The international environmental management system standard **ISO 14001** defines an **environmental aspect** as an:

> *"element of an organisation's activities or products or services that can interact with the environment".*

So, one environmental aspect of the power station's activities is the emission of exhaust materials from its chimneys into the atmosphere. But why does this matter? What is the environmental damage, or impact, that might result from this aspect?

There is a very useful model that is often used to identify and characterise environmental impacts in these types of situation. It has the following elements:

- **Source:** Is there a source of contamination? This might be a toxic chemical, a physical substance such as dust or grit, or energy in the form of heat, noise, or light.
- **Receptor:** Is there something that can be harmed or damaged by this contaminant? This might be wild animals or plants, humans, eco-systems (e.g. rivers, forests), or global systems, such as the climate.
- **Pathway:** Is there a route by which the contaminant can reach a receptor? For example could the contaminant reach a receptor through the atmosphere, or possibly via a drainage system?

If we can make the link:

Source ⟶ Pathway ⟶ Receptor

then we have an **impact**.

**ISO 14001** defines an environmental impact as:

> *"any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's aspects".*

If we apply the source-pathway-receptor model to the emission of exhaust materials from the coal-fired boiler in the power-station, we find that this single aspect can have a number of quite different impacts. This is because there is a number of different contaminants associated with this aspect, that can move via a number of different pathways to reach a number of different receptors.

For example, local residents could be affected by smoke and grit in the boiler exhaust, which passes up the chimney and into the local atmosphere and is then deposited over the neighbouring land. The smoke and grit could be a nuisance, e.g. creating dirty deposits on washing and cars, or people might suffer health effects if they are susceptible to breathing problems, e.g. due to asthma or bronchitis.

But there are also other types of contaminant (besides smoke and grit) contained in the exhaust emission. One of the main components of the power-station exhaust is carbon dioxide. This is one of the main greenhouse gases and contributes to global warming and climate change.

Another important component of the exhaust is the gas sulphur dioxide. If this gets into the atmosphere it can be transported many hundreds of miles by the prevailing wind. Sulphur dioxide can react with moisture in the atmosphere to create 'acid rain'. This has been shown to be damaging forests and lakes in countries as far away as Norway and Sweden.

So, the emission of exhaust materials from the power station's chimneys into the atmosphere – a single **environmental aspect** – can potentially result in a number of different **environmental impacts**, which involve different contaminants, pathways and receptors. In summary:

**Environmental aspect:** Emission of exhaust materials from coal-fired boiler.

| Source (contaminant) | Pathway | Receptor | Environmental impact |
|---|---|---|---|
| Smoke and grit particles | Released via chimney into the local atmosphere. Deposited on the ground close to the power station. | Local residents | Dirty washing |
| Smoke and grit particles | Released via chimney into the local atmosphere. Deposited on the ground close to the power station. | Local residents | Respiratory problems |
| Sulphur dioxide | Released via chimney into the atmosphere.<br>Carried by the prevailing wind and deposited as acid rain over Scandinavia. | Norwegian salmon | Declining fish stocks |
| Sulphur dioxide | Released via chimney into the atmosphere.<br>Carried by the prevailing wind and deposited as acid rain over Scandinavia. | Norwegian trees | Forest die-back |
| Carbon dioxide | Released via the chimney into the global atmosphere. | Global atmosphere | Climate change |

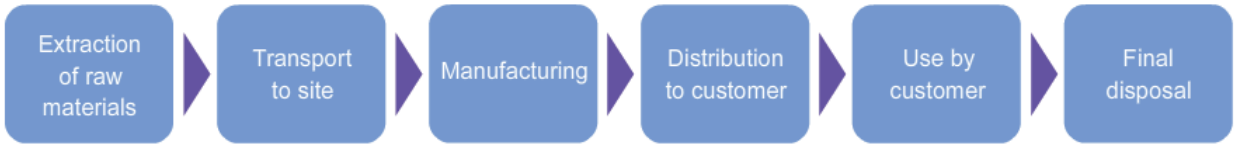
## CRADLE-TO-GRAVE CONCEPT (LIFE-CYCLE ANALYSIS)

The source-pathway-receptor model that we looked at above is very useful in situations where an organisation is directly releasing contaminants or pollutants into the environment from its own activities, such as:

- exhaust emissions from a boiler; or
- discharges of liquid effluent from a manufacturing process.

Many organisations, especially in the service sector, may not, however, operate equipment or processes that make significant releases of contaminants directly into the environment. The environmental impacts of these organisations are more likely to be associated with the products and services that they supply or purchase.

Life-Cycle Analysis (LCA) is a tool to identify and measure the environmental impact of a product or service throughout its life cycle – from cradle to grave. This information can then be used to inform the decision-making process regarding new products or to make changes to materials used in existing products.




Possible life cycle of a product

The **ISO 14040** series provides guidance on aspects of LCA. The idea is to collect data on inputs at each stage of the life cycle, such as the use of raw materials and energy, and outputs for each stage, such as emissions to air, water and waste products. This allows an evaluation of the environmental impact of each stage in the life cycle, as well as for the product as a whole.

This cradle-to-grave approach helps identify the **total impact** a product has on the environment. One example of this is the often-discussed argument over the use of disposable or washable nappies for babies. For some years now, there has been a belief that washable nappies are significantly better for the environment than disposable nappies. This is because disposables usually end up in landfill and can take hundreds of years to decompose, thereby continuing to take up space and contribute to the generation of landfill gas containing methane – a known contributor to climate change. However, the counter argument to this is that washable nappies consume large amounts of energy during their lifetime because of the need to wash them frequently and often at high temperature. A report in 2005 by the Environment Agency, *Life-Cycle Assessment of Disposable and Re-usable Nappies in the UK*, studied the life-cycle impacts of three nappy systems:

- Disposable nappies.
- Home-laundered, flat-cloth nappies.
- Commercially-laundered, pre-folded cloth nappies delivered to the home.

The report concluded that over a complete life cycle "there was no significant difference between any of the environmental impacts – that is, overall no system clearly had a better or worse environmental performance, although the life-cycle stages that are the main source for these impacts are different for each system." The report calculated that the impacts for one child, over a normal two-and-a-half-year period, were approximately the equivalent of driving between 1,300 and 2,200 miles.

The report has faced criticism. For example, some of the energy usage calculations were based on standard high-temperature washes; there are now modern low-temperature alternatives. The argument is on-going, with both disposable and reusable nappy producers commissioning reports of their own and showing different results. This highlights one of the difficulties of LCA; it is essential that the scope, assumptions and methodology of the study are clearly laid out in the final report, as a change in any of these can significantly alter the final result.

Two further examples of the use of LCA are the comparison of the environmental impacts of low ethanol-content diesel blends (e-diesel) with traditional fuels, and what type of packaging materials have the least impact overall on the environment.

LCA has a number of other potential applications, with associated benefits being:

- Increased efficiency and saving – the process allows the tracking of energy flows through a production process and the highlighting of areas where savings can be made.
- Product marketing – information gained during the process can be used to highlight the environmental benefits of the product, thereby attaching a potentially new Unique Selling Point (USP) to the product and differentiating it from other, similar products in the market place.

**MORE...**

For information on 'green' labels, go to:

www.defra.gov.uk/environment/economy/products-consumers/green-claims-labels

## Principles and Techniques of Life-Cycle Analysis

The LCA process can be applied to a product whenever there is an input to or output from the product. A full LCA of even a simple product is a long and complex process and it is beyond the scope of this course to discuss it in detail.

**TOPIC FOCUS**

**ISO 14040** identifies four stages in the **LCA process**:

- **Definition of goal and scope** – an important and early decision is the purpose and coverage of the LCA. Which stages of the life cycle and which inputs and outputs are to be assessed?
- **Inventory analysis** – this is the data collection stage, where inputs and outputs are identified and quantified.
- **Impact assessment** – once the data has been collected and quantified in the inventory analysis stage there will need to be some assessment of the impact of those inputs and outputs on the environment. This may involve attaching the inventory data to a known impact category. For instance:
  - Oxides of sulphur and nitrogen may be allocated to an impact such as acid rain.
  - Greenhouse-gas emissions may be allocated to a global warming category.
- **Interpretation of the results** – this final stage brings all the data gathered in the previous stages together and allows for conclusions and recommendations to be drawn from the results. The outcome of this process may be changes to the product design, or how it is made. It may also provide marketing material to help position the product more favourably in the marketplace.

**REVISION QUESTIONS**

1. Outline what is meant by the terms 'environmental aspect' and 'environmental impact'.
2. What is Life-Cycle Analysis?

(Suggested Answers are at the end.)

# Types of Environmental Impact

## KEY INFORMATION

Environmental impacts can be categorised in a number of ways:

- whether they are direct or indirect;
- by the media they pollute; or
- whether they are positive or negative impacts.

## DIRECT AND INDIRECT IMPACTS

Impacts can arise as a direct result of an organisation's activities. For example, in the case of the coal-fired power station that we looked at earlier, the operator of the power station clearly has management control and responsibility for the facility. The environmental impacts associated with the power station are therefore the operator's **direct** environmental impacts.

But we all use electricity, don't we? We create a demand for electricity, and the more electricity we use, the more emissions the power station makes. We also have some capacity to reduce the environmental impacts associated with electricity generation by using less energy. We therefore accept some responsibility by recognising the consumption of electricity as an **indirect** environmental impact of our activities.

Indirect environmental impacts are associated with many of the goods and services that we buy. For example:

- Use of a third-party distribution contractor (air pollution from trucks).
- Purchase of paper (cutting down forests; pollution from paper mills).

For many organisations, especially in the service sector, indirect environmental impacts may therefore have a very high significance in their environmental programme.

## CONTAMINATION OF THE ATMOSPHERE

This is almost impossible to control once a pollutant is emitted to the atmosphere. The effects may not only be local but can be national or international (transboundary). Air pollution can also have significant adverse health effects.

## CONTAMINATION OF LAND

This can lead to restricted use of land in the future or entail significant clean-up costs. Pollution of land can also lead to pollution of water sources, either by percolation through to groundwater, or by surface water run-off to rivers and streams.

## CONTAMINATION OF THE AQUATIC ENVIRONMENT

Once in an aquatic environment, pollution can travel long distances and cause adverse effects significant distances from the original source. If groundwater becomes polluted, it may be extremely difficult to effectively clean the water so that it is wholesome again.

## EFFECTS ON THE COMMUNITY

Local residents may benefit from development. For example, a mixed development that combines commercial, cultural, institutional, or industrial uses can provide a number of benefits for a neighbouring residential community, such as:

- Creation of jobs.
- Reduced travel between homes, workplaces and retail and leisure facilities.
- Provision of more open spaces and pedestrian and cycle paths.
- Improved landscaping through tree planting and the creation of nature habitats.

However, there may also be negative impacts on the local community:

- Noise and vibration.
- Increased traffic causing congestion, dust and odour.
- Loss of open space.
- Polluted watercourses.
- Loss of visual amenity – a wide-open view of the countryside will be preferable to a large industrial development.

Polluted sea shore, as well as loss of visual amenity

## EFFECTS ON THE ECOSYSTEM

Ecosystems are a collection of individual habitats (places inhabited by various forms of wildlife). Damage to a number of linked habitats will eventually have a harmful impact on the surrounding ecosystems. On the positive side, however, certain developments, such as the remediation and development of a contaminated site (e.g. an old landfill), or planting trees on previously arable land, might have several benefits in terms of the restoration or creation of wildlife habitats.

Re-afforestation may also have several benefits beyond habitat creation, such as:

- Acting as a carbon soak - carbon dioxide sequestration. (Trees use carbon to create energy and naturally remove carbon dioxide from the atmosphere for this purpose. The tree acts as a long-term carbon-storage reservoir.)
- Improved water quality (remember, arable land may be being displaced, reducing the amount of agricultural fertiliser ending up in local rivers).
- Reduced soil erosion (rain infiltration rates tend to be higher, so there is less surface run-off).
- Flood control (again, because surface run-off is reduced).

All of these can affect both humans and animals.

## USE OF RAW MATERIALS AND NATURAL RESOURCES

The use of non-renewable raw materials depletes the Earth's resources and leaves fewer options for future generations. Activities such as mining and quarrying of raw materials are also likely to have a significant direct impact on the local environment.

## REVISION QUESTION

3. Consider a vehicle repair garage. Which of the following environmental aspects will have impacts that are direct, and which will have impacts that are indirect?
    - Air emissions from running vehicle engines in the workshop.
    - Air emissions from a waste oil burner used to provide heat for the workshop.
    - Methane gas generated from a landfill site that disposes of the garage waste.
    - Accidental spillage of oil into the public sewer at the garage.
    - Use of electricity from the energy provider to heat offices.
    - Purchasing of office desks, made from non-renewable hardwoods.
    - Contamination of the land through spillages of oil and fuel in the workshop.
    - Water discharges caused in the manufacture of engine parts.

(Suggested Answer is at the end.)

# Nature and Key Sources of Environmental Information

## KEY INFORMATION

- Various internal and external sources of environmental information are available to assist an organisation in assessing impacts.
- Supply-chain issues should also be considered.

To identify significant aspects and impacts, you need information about your organisation's activities.

## INTERNAL TO THE ORGANISATION

## TOPIC FOCUS

**Sources of Environmental Information Internal to the Organisation**

- **Inspection/audit reports**: identify any evidence of defects and a lack of suitable controls.
- **Incident data and investigation reports**: indicate where there has been a failure in a process or procedure. The frequency and extent of such a failure will help determine the probability and severity of such an incident. Investigation will help determine causes and additional controls.
- **Maintenance records**: provide information on machine reliability and types of failures experienced in the past. This can be used as an indication of what may occur in the future and therefore what precautions need to be put in place.
- **Job/task analysis**: although usually used to identify safety hazards, a thorough analysis of tasks - by breaking them down into smaller steps - may help identify potential environmental impacts from the activity.
- **Environmental monitoring data**: the results can show trends, such as pollution levels increasing slowly over a period of time, and identify any times of increased risk when it may be necessary to implement stricter controls.
- **Raw-material usage and supply**: volumes of raw material used should be consistent with the volumes of final product produced. If there are significant changes this may be an indication of a problem in the production process. Consideration should also be given to the sources of supply and the potential impacts this may have, e.g. using timber from a sustainable supply.
- **Environmental permits**: will provide detailed information on what activities may be carried out and the levels of pollution that are permitted from those processes. They will usually also include details on how frequently monitoring must take place and what parameters must be monitored, such as total volume, rate of discharge, suspended solids, etc.

## EXTERNAL TO THE ORGANISATION

### TOPIC FOCUS

**Sources of Environmental Information External to the Organisation**

- **Manufacturers' data**, including information such as Material Safety Data Sheets and operating or maintenance instructions.
- In many countries, **legislation** is made freely available online, or available to purchase as a hard copy.
- **Enforcement bodies** publish guidance documents on compliance with environmental law and promoting good practice.
- **Government-supported organisations** whose role is to support and encourage environmental improvements in specific areas. Examples of these in the UK include the Waste and Resources Action Programme (WRAP) (www.wrap.org.uk/) and the National Industrial Symbiosis Programme (www.nispnetwork.com).

  The European Environment Agency body produces information for member states on environmental issues.
- **Trade associations** (such as the Chartered Institution of Wastes Management (CIWM), the Royal Institution of Chartered Surveyors (RICS), the Mineral Products Association and many others in the UK, for example) can provide specific advice and information on the areas of expertise in which they operate.
- **Professional institutions** (such as the Institution of Occupational Safety and Health (IOSH) and the Institute of Environmental Management and Assessment (IEMA) in the UK) exist to provide support to professional members and to promote a higher standard of training and competency for those working in these areas. Many of them also have a wide range of consultancy services and technical information available.
- **International Organisation for Standardisation/British Standards Institution** publish the standards such as **ISO 14001:2015** for environmental management systems and often have guidance documents to support these standards.
- **Commercial organisations** such as Barbour, Technical Indexes, etc. all offer either online, CD or book-based systems for accessing legislation and guidance. Some of them also offer specific helpline services and documents, such as checklists and form templates.
- **Encyclopaedias and textbooks** are also available.

### REVISION QUESTION

4. List three sources of environmental information that are internal to the organisation and three sources of information that are external to the organisation.

(Suggested Answer is at the end.)

## KEY INFORMATION

- Impact assessment can be linked to the initial environmental review undertaken in **ISO 14001**.
- Different operating or unplanned conditions should be considered when assessing environmental impact.
- The concept of Source, Pathway, Receptor is critical in assessing environmental impact.
- Semi-quantitative assessments is a common method for determining the significance of an environmental impact.
- Environmental impact assessments should be recorded and reviewed periodically.

When implementing a new Environmental Management System (EMS) from scratch, an organisation's significant aspects and impacts would normally be identified at the initial environmental review stage (see Element 2). The policy and objectives would then be developed realistically based on knowledge of the specific environmental risks arising from the organisation's activities.

### CONTEXT

The impact types discussed earlier are usually considered within a number of contexts:

- **Direct/indirect**: as discussed earlier.
- **Normal/abnormal conditions**: all planned activities need to be considered. These will include not only those associated with normal running but also those associated with the non-routine ('abnormal'), such as maintenance and cleaning.
- **Accidents/incidents/emergencies**: reasonably foreseeable incidents should also be considered, e.g. fire or chemical/oil spillage.
- **Past/future activities**: you should consider the impact from past and planned activities. For example, past land contamination has impacts that continue into the present. Business plans, such as increasing production, will also have future impacts that should be taken into account.

### CONCEPT OF SOURCE, PATHWAY, RECEPTOR WHEN ASSESSING ENVIRONMENTAL RISK

The concept of Source Pathway Receptor (SPR) – sometimes referred to as Source Pathway Target – that we introduced earlier is fundamentally useful in assessing environmental risk. The SPR approach can be used to identify potential effects on any environmental media (air, water, and land).

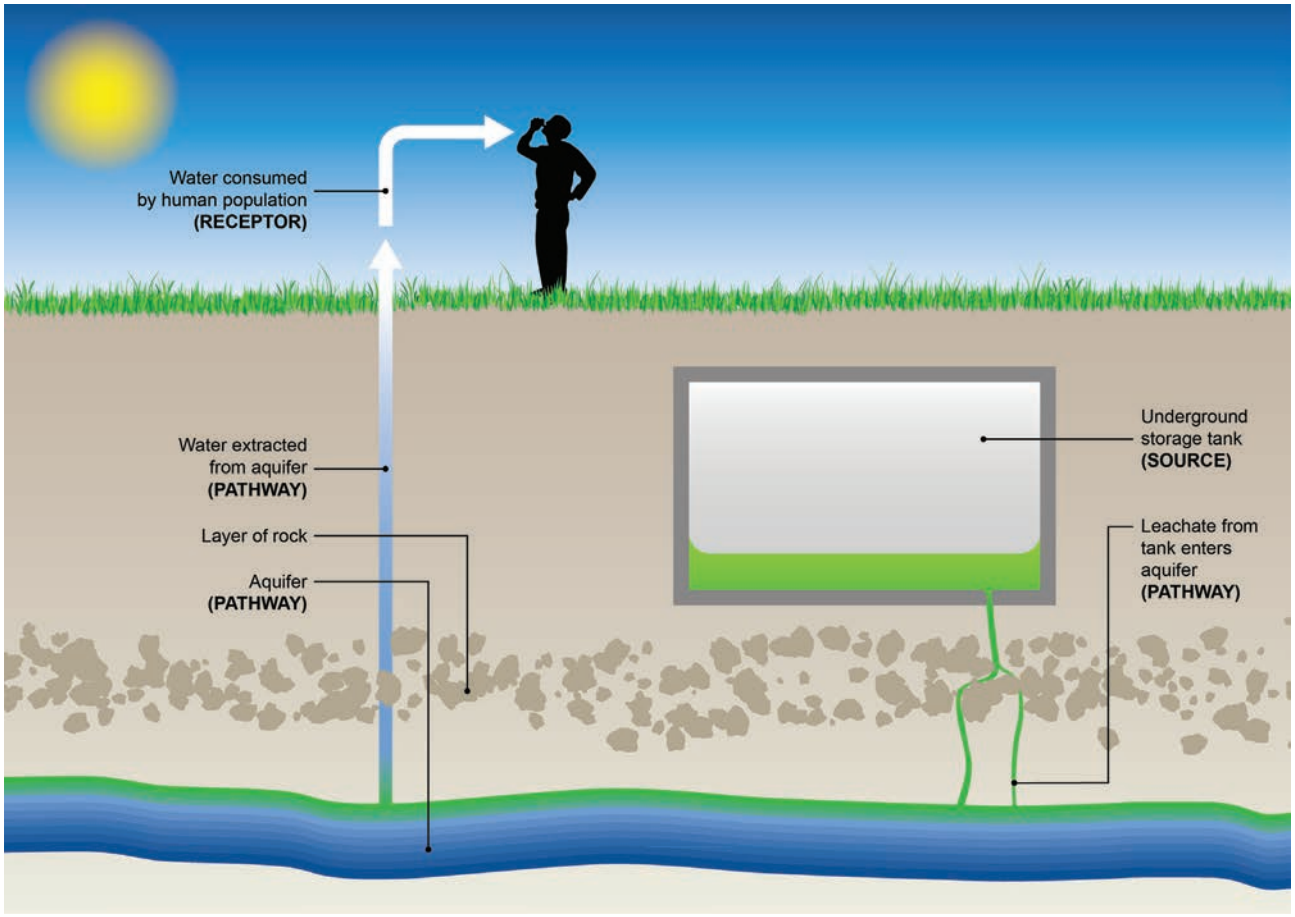
## TOPIC FOCUS

**Example of the SPR Approach: A Petrol-Filling Station**

There are numerous sources, pathways and receptors here, of which the following are examples:

SPR Analysis

| Source | Pathway | Receptor |
|---|---|---|
| Underground fuel tank | Product loss and dissolution in groundwater | Groundwater in aquifer |
| | Vapour transport through soil | Humans |
| Fuel dispenser | Air-inhalation | Humans |
| Spills by users | Forecourt drains | Local watercourses |




Source, pathway and receptor – an example

**Note**: Pathways may also be receptors (such as in the case of a watercourse), and receptors can include people or land of varying sensitivities.

You will appreciate that a great amount of analysis is required to understand environmental harm. Although the receptor may be a watercourse, the effect may be on the fish or invertebrate life in that watercourse, or to the humans or others who have use of that water, whether as drinking water for people or animals, or for recreational or industrial use.

## SPECIFIC IMPACTS

### International Impacts

As we discussed earlier, there are numerous international impacts that should be considered when carrying out an environmental impact assessment. These include:

- Climate change.
- Ozone depletion.
- Acid deposition.
- Water pollution (where watercourses pass international boundaries).
- Waste disposal (where waste is transported from one country to another), etc.

### Resource Abstraction

Taking resources from the environment can have numerous impacts on the environment. Deforestation – the removal of naturally-occurring forests by human activities such as logging or the burning of trees – is associated with significant environmental problems. Deforestation may occur for a number of reasons, such as clearing land for cattle, settlements or agricultural plantations and the use of wood for charcoal.

The removal of trees without sufficient replanting leads to several problems, including:

- Damage to habitats.
- Biodiversity losses.
- Soil erosion, which allows fertile soil to be washed into rivers, leaving behind wastelands.
- Removal of a key carbon sink, increasing the amount of carbon dioxide in the air.

## Pollution from Mining

The impacts on the environment of metal extraction, for example, can be significant and include:

- Deforestation to make way for mines.
- Rock waste from surface mining is typically deposited on land close to the mine, covering areas that are vegetated.
- Mine waste (known as tailings) can leach into nearby rivers and other types of watercourses, causing them to become clogged and flooded.
- Metals present in the mine waste can pollute rivers and other surface waters, seriously affecting aquatic life. Sulphur in mines can combine with water to form sulphuric acid, creating acid mine drainage.

## Transport

In the control of air pollution, transport effects include the emission of combustion gases, such as carbon dioxide, carbon monoxide, nitrogen and sulphur oxides ($NO_x$ and $SO_x$), particles and, in lesser quantities, up to 40 other gases, such as butadiene and benzene.

Other effects of traffic should not be overlooked, including:

- Nuisance caused by noise or dust.
- Congestion causing air pollution and nuisance.
- Changes to the landscape affecting aesthetics.
- Land-take causing reduction in diversity.
- The effects of refuelling causing water pollution from spillage.

## Waste Disposal

The impacts of waste disposal can be significant and we will cover these in more detail later. They include:

- Noise from waste transportation and site activities causing nuisance.
- Odours from landfill sites or waste incineration causing nuisance.
- Dust and litter causing nuisance.
- Release of methane containing landfill gas causing climate change and presenting a fire and explosion risk to those near the site.
- Leachate discharged from a landfill causing water pollution.

## IDENTIFYING RECEPTORS AT RISK

It is essential that potential receptors are identified early in the process. Some of these are discussed below.

## Flora

Carry out an ecological assessment on the surrounding flora such as reedbeds, hedgerows and local woodland. This is likely to require specialist knowledge and monitoring to be conducted over at least a 12-month period to account for seasonality.

## Fauna

Carry out an ecological assessment on the surrounding fauna, including habitat of bats, birds and badgers. This should also include a protected species survey that would need to be completed at the appropriate time of year for invertebrates, small mammals (including bats, dormice, water voles) and nesting birds.

## Watercourse

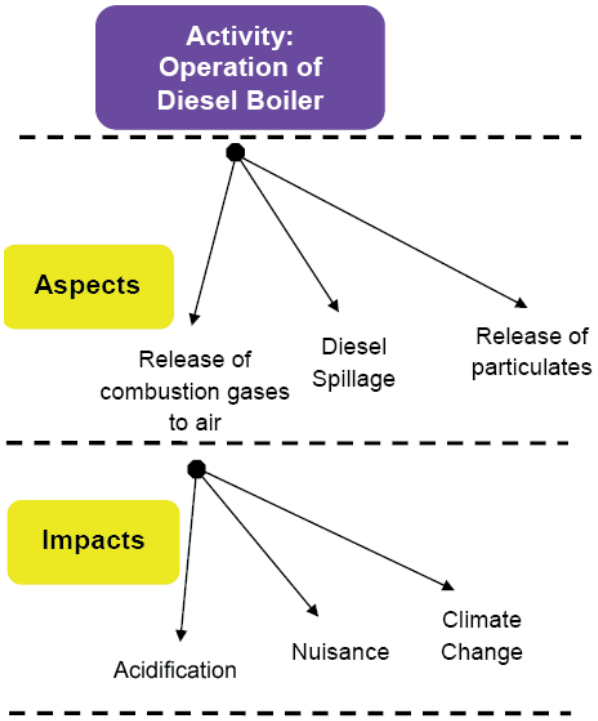
Assess the potential impacts on groundwater and surface drainage ditches and conduct a survey of water abstractions to establish the number of licensed and unlicensed abstractions and their proximity to the site.

## Local Populace

Impacts could include air and climate, noise and vibration, cultural heritage, landscape and visual impacts, as discussed earlier. The impacts on indigenous people must be considered, where relevant, when assessing the risk to the local populace.

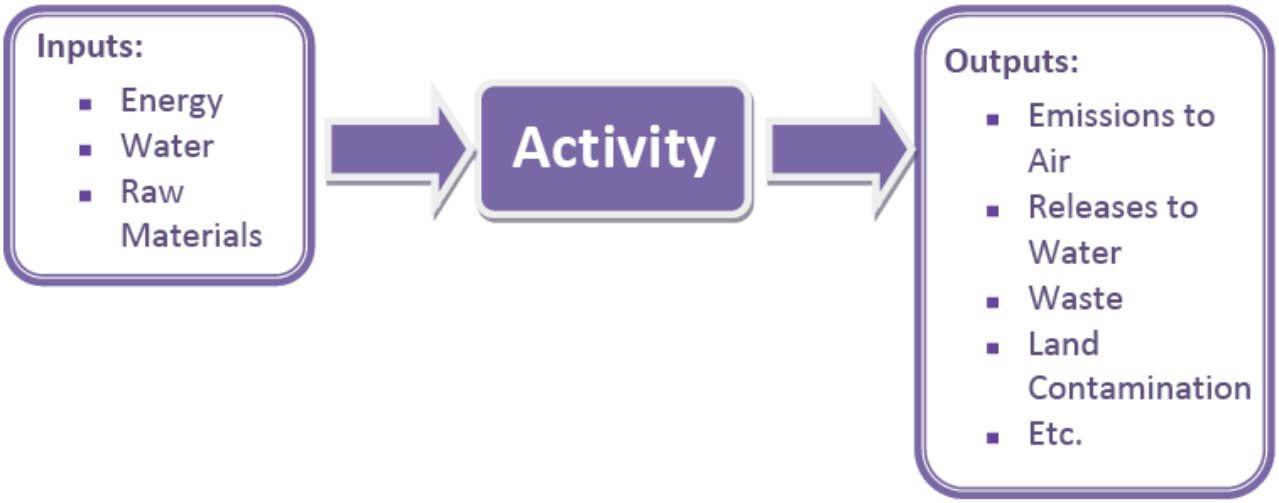
## IDENTIFICATION OF ASPECTS AND IMPACTS

The organisation's environmental aspects and associated impacts now need to be identified, making use of the SPR model for direct aspect/impacts, and the Cradle-to-Grave approach for indirect aspects/impacts, as appropriate.




Example of aspects and impacts for the operation of a diesel boiler

There are many ways to record aspects and impacts. A common approach is to break a site down into functions or processes and then look at the activities or services associated with each. For each activity, you can then consider its inputs (raw materials, etc.) and outputs (solid waste, etc.). A checklist can be used for this purpose. Once these have been identified it is necessary to establish which of those aspects are significant and need to be controlled. This is discussed below.




Input/output method of identifying environmental aspects

## EVALUATING IMPACT AND ADEQUACY OF CURRENT CONTROLS

Having systematically identified all of the environmental impacts of all of its activities, most organisations will be faced with a very long list. It will usually be unfeasible to address all of these impacts immediately, and some impacts may be so small as to be considered trivial.

Clearly, some process is needed to analyse the long list of impacts and to determine which of these are significant and should therefore be given priority.

There is no single system for determining the significance of impacts. But many organisations already have a well-established system for health and safety risk assessments, which can easily be adapted to cover environmental impacts.

The most common methods for determining significance are semi-quantitative assessments, which use a scoring matrix to combine relative scores for the likelihood that an impact will occur and its severity if it does so.

This approach generally works well, but it must be emphasised that a good deal of judgment is required, and although numbers are used these are only indicative and do not confer absolute validity.

An example of a matrix system is shown below. The way it works is that each impact is given two scores on a scale of 1-5. The first score expresses the relative likelihood that an impact will occur and the second the severity of the impact should it actually happen. Simple criteria have been documented to guide the award of scores.

The individual scores for likelihood and severity are then multiplied to give an overall assessment score. The overall scores can then be filtered into 'High', 'Medium' and 'Low' bands to determine the level of significance.

### GLOSSARY

**QUANTITATIVE**

Usually measured in some way and quantified, e.g. measured emissions from a process.

**QUALITATIVE**

Based on some quality rather than quantity - usually a subjective judgment, e.g. 'good' and 'bad', or 'low', 'medium' and 'high'.

**ASSESSMENT SCORES**

| Severity | Likelihood |
|---|---|
| 1. No impact | 1. Rare |
| 2. Minor and temporary impact | 2. Unlikely |
| 3. Minor but permanent impact | 3. Probable |
| 4. Major impact | 4. Very likely |
| 5. Major impact in breach of legislation with risk to health | 5. Certainty |

**SIGNIFICANCE FACTOR**

Severity x Likelihood then gives overall Significance Factor (minimum = 1; maximum = 25)

**SIGNIFICANCE ASSESSMENT**

| | |
|---|---|
| Low | 1 – 7 |
| Medium | 8 – 15 |
| High | 16 – 25 |

Semi-quantitative environmental risk assessment matrix

The risk assessment will, of course, look at existing controls and, if considered inadequate in relation to the risk, recommend further controls.

## ACTIVITIES OF SUPPLIERS

As we have already seen, the activities of suppliers can result in significant indirect environmental impacts for some organisations. Retailers and other organisations in the service sector may be particularly exposed to the environmental performance of their suppliers. Examples of purchases with potentially significant indirect impacts include:

| Consumption/ purchase | Potential direct impacts |
|---|---|
| Electricity | Air pollution from the operation of power stations |
| Distribution services | Air pollution and noise from heavy trucks |
| Waste-disposal services | Land and groundwater contamination. Air pollution |
| Paper and card | Poor forestry practices and pollution from paper mills |
| Construction services | Noise, dust and other nuisance |
| Food products | Loss of habitat for farming and pollution from pesticides |

## RECORDING SIGNIFICANT ASPECTS

Environmental aspects and impacts are often recorded in the form of a register. Although there is no set format for an aspects and impacts register, as a minimum they will often contain the following information:

- Activity that has been assessed.
- Environmental aspects associated with the activity.
- Environmental impact associated with each aspect.
- Identification of whether the aspect is from normal, abnormal, or emergency context.
- Identification of the results of the assessment against significance criteria – for example, likelihood, consequence and total scores if using a semi-quantitative method to assesses significance.

## REVIEWING

### Reasons for Review

Any risk assessment is, by necessity, a snapshot of the situation as it is at the time the assessment takes place. It may be necessary to review the assessment if:

- An incident relevant to the assessment occurs, particularly if there appear to be inadequate controls.
- Processes and/or equipment changes.
- Staff changes, particularly if there is a loss of experience and/or historical knowledge.
- Legislation changes, imposing more onerous or new requirements.
- There has been a lapse of time since the last review – technology moves on, and what is considered the best available technique, or best practicable environmental option today, may not be in the future.

## REVISION QUESTION

5. Identify three criteria that might be used in deciding whether an environmental impact is significant or not.

(Suggested Answer is at the end.)

# Summary

## SUMMARY

This element has dealt with the principles and practice of Environmental Impact Assessment (EIA).

In particular, this element has:

- Shown that the main objectives of an EIA are to identify environmental impacts of an activity, suggest measures to prevent or reduce negative impacts, identify monitoring strategies, and incorporate environmental information into the decision-making process.
- Outlined the stages of an EIA, including screening, scoping, baseline studies, impact assessment significance, mitigation, application and environmental statement, and monitoring.
- Explained how Life-Cycle Analysis identifies and measures the environmental impact of a product or service throughout its life cycle – from cradle to grave. The information can be used to inform the decision-making process regarding new products, or to make changes to materials used in existing products.
- Shown that environmental impacts can be categorised in the following way:
  - Direct and indirect.
  - Contamination of the atmosphere.
  - Contamination of land.
  - Contamination of the aquatic environment.
  - Positive and negative effects on the community and on the ecosystem.
- Identified many sources of information available relating to an organisation's activities:
  - Internal, e.g. inspection/audit reports; maintenance records, etc.
  - External, e.g. manufacturers' data; enforcement bodies, guidance documents, etc.
- Described the principles and practice of impact assessment, including:
  - The concept of Source, Pathway and Receptor – identifying potential effects on any environmental media.
  - Examples of specific impacts (including international impacts, resource abstraction, pollution from mining, transport and waste disposal).
  - Identification of receptors at risk (flora, fauna, etc.).
  - Identification of the organisation's environmental aspects and impacts and significant environmental impacts (impacts may not always be negative).
  - Evaluation of the significance of each impact (e.g. severity × likelihood).
  - Considering the activities of suppliers, in particular the significant indirect environmental impacts for retailers and other service sector organisations.
  - Recording any significant findings.
  - Reviewing the assessment as and when necessary.

## QUESTION

20

A large supermarket chain wants to reduce the environmental impact of its stores.

(a) **Identify FOUR** significant environmental aspects associated with the operation of its stores. (4)

(b) **Outline FOUR** measures that could be implemented to reduce the impact of **ONE** of the aspects identified in part (a). (4)

### APPROACHING THE QUESTION

As before, using good exam technique, you must:

- Read the question.
- Consider the marks available. In this case, there are eight marks available so you should spend around nine minutes answering the question and provide eight pieces of significantly different information. (**Note**: you may spend slightly less than four minutes on part (a), as it is an 'Identify' question requiring a short answer.)
- Highlight the key words. In this case, the key words would include:

  (a) Identify, FOUR, significant environmental aspects.

  (b) Outline, FOUR, measures, impact, ONE of the aspects identified in part (a).
- Read the question again.
- Jot down an outline plan.

  (a) is an 'Identify' question, requiring a short answer and so does not require a plan.

  (b) One of the following:

  – Energy use – climate change, acid rain, sources renewable, lighting improvements, on-site generation, insulation.

  – Transportation – climate change, acid rain, alternative fuels, regular maintenance, driver training, car sharing.

  – Waste – impacts of landfill, waste minimisation, re-use of wastes, long-lasting bags, segregation, recycling.

  – Packaging – resource consumption, climate change, landfill, pressuring suppliers, easily recycled, information on recyclability, sustainable sourcing.

  A word of caution: ensure that for (b) you base your four improvement measures on one of the aspects identified in (a). You will not gain any marks if the improvements are not relevant to the aspect you identified in (a).

### SUGGESTED ANSWER

Now you have finished your answer, read the suggested answer below and compare it to your answer.

(a) Aspects related to transportation (e.g. air emission), energy use, packaging, waste production.

(b) One of the following:

Impacts associated with energy use can include climate change and acid-rain production. These can be reduced by the store purchasing electricity that has been generated from a renewable source, such as hydropower, solar power, etc. The organisation could also improve its lighting by fitting more efficient lighting (e.g. compact fluorescent bulbs), optimising the amount of lighting and fitting lighting controls in appropriate areas such as movement sensors in corridors. The organisation could also implement on site alternative energy-generation systems, such as using solar photovoltaic panels on store roofs that will generate electricity for the site with surplus being passed to the national grid. The organisation could also fit insulation to its stores, as this will mean that less heating of the building will be required during colder periods of the year.

Transportation can have numerous impacts, such as climate change, acid rain, reduction in biodiversity, etc. By using alternative fuel vehicles for deliveries or supply this will reduce the amount of carbon dioxide emitted. Liquefied Petroleum Gas (LPG), for example, emits lower levels of greenhouse gases when combusted than petrol or diesel.

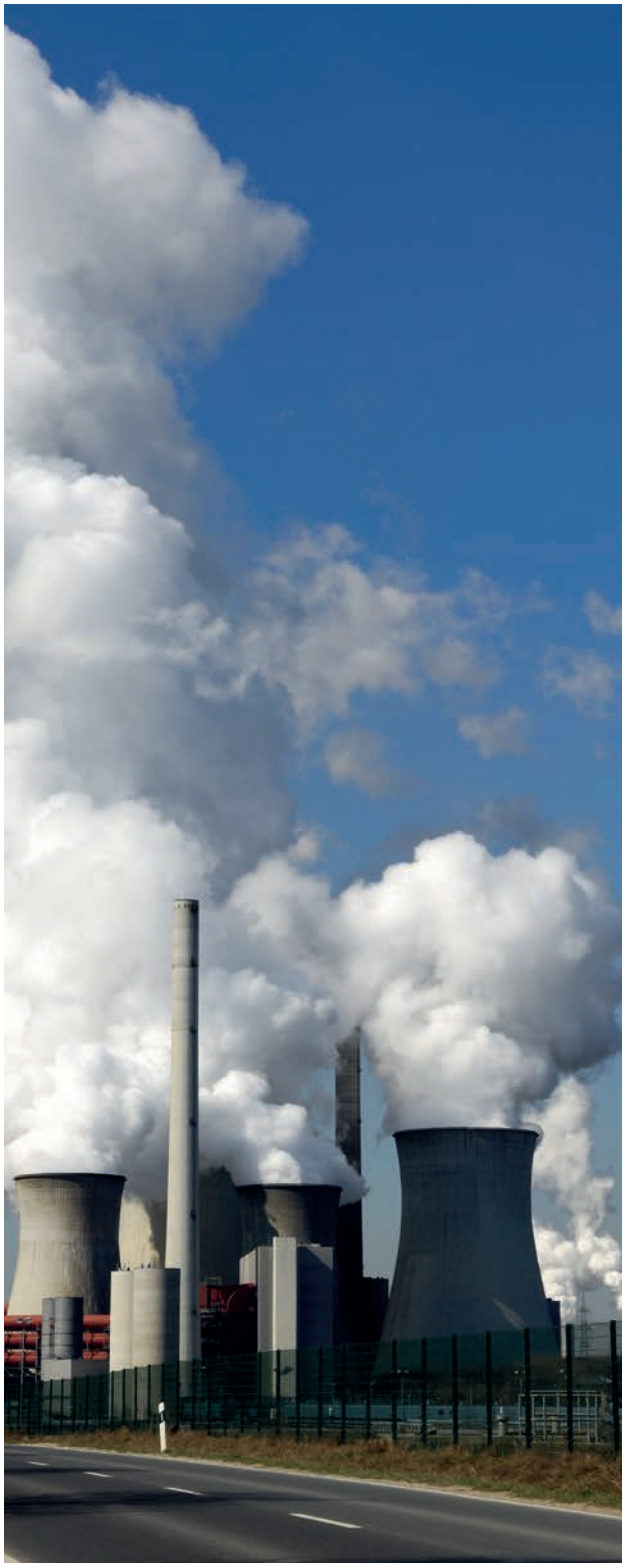
The organisation could also ensure that regular maintenance is undertaken on company vehicles. Simple measures such as regular tyre-pressure checks can result in much improved efficiency. Driver training could also be provided in techniques to reduce fuel use and emissions, such as avoiding inappropriate acceleration. The organisation could also promote the use of car sharing to staff by operating a car-share system.

Numerous wastes can be produced by the organisation. It is likely these will end up in landfill causing numerous impacts such as nuisance, climate change and water pollution. Implementing a waste minimisation programme would assist in reducing the amount of waste that goes to landfill. This might include the organisation re-using certain items of packaging for other uses at the site, e.g. boxes could be provided for customers to carry goods. Offering more long-lasting carrier bags and giving customers an incentive to re-use carrier bags could also be implemented (e.g. points on a loyalty card). The organisation could also segregate its general waste such that plastics, cardboard, etc. are separated and sent for recycling. The company could also pressure suppliers to reduce the packaging on products that are deemed to be over-packaged.

Impacts associated with packaging are many and can include resource consumption, climate change, impacts of landfill, etc. Ways to reduce packaging include pressuring suppliers of products to optimise packaging where it is not required. The company should also ensure that the packaging chosen can be easily recycled. The packaging should also contain information (such as text and/or symbol) that identifies whether it can be recycled. The store should also ensure that packaging is made from a sustainable source, e.g. in the UK Forest Stewardship Council (FSC)-accredited cardboard should be used.

# CONTROL OF EMISSIONS TO AIR

ELEMENT 4



## LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Outline the principles of air quality standards.
2. Outline the main types of emissions to atmosphere and the associated hazards.
3. Outline control measures that are available to reduce emissions.

# Contents

## KEY INFORMATION

- Air pollutants are measured in parts per million (ppm) or milligrams per cubic metre ($mgm^{-3}$).
- There is a number of health effects associated with poor air quality. These include short-term irritation and inflammation, long-term respiratory problems and, in some cases, an increased incidence of cancers.
- Standards of air quality are set under the European Union **Directive 2008/50/EC** on standards of air quality for certain pollutants. The aim is to protect the environment and human health.

The quality of the air that surrounds us is critical to health and the enjoyment of life. Poor air quality may also have detrimental impacts on wildlife and agricultural systems. But pollution of the air we breathe has been a problem for centuries, as cities have grown larger and human society has become more industrialised. Although progress has been made in controlling some sources of air pollution, air quality is still declining in many areas of the world, especially in large cities with high densities of road vehicles. Air-Quality Standards are an important tool for regulators in controlling levels of the atmospheric pollutants to which we are potentially exposed.

## MEANING AND USES OF PPM AND $MGM^{-3}$

Levels of contaminants in the atmosphere are typically expressed in units of either 'ppm', or '$mgm^{-3}$'; it is important that we clearly understand the differences between these measures.

The unit 'ppm' is shorthand for parts-per-million. This is a way of denoting the relative proportion of a contaminant in a sample of air, usually on a volume basis. For example, if a sample of air of one litre in volume contains one-millionth of a litre of a pollutant, then the level of the pollutant may be expressed as 1ppm. The unit ppm is typically (although not always) used for pollutants that exist in the atmosphere as gases or vapours.

The unit $mgm^{-3}$ expresses the concentration of a pollutant in terms of the mass (milligrams) of the substance present in a given volume (one cubic metre) of air. For example, if a sample of $1m^3$ of air is found to contain 10mg of dust particles, then the concentration of dust may be expressed as $10mgm^{-3}$. The unit $mgm^{-3}$ is typically used for contaminants that exist in particulate form.

## THE POTENTIAL EFFECTS OF POOR AIR QUALITY

We have seen (Element 1) that pollution may have local, regional and global impacts. This is especially relevant when considering the potential impacts of air pollution because of the ability of some contaminants to be transported significant distances through the atmosphere.

Local air pollution, especially in towns and cities, is a continuing focus for regulators because of the health impacts of ground-level pollution, such as city smog. The World Health Organisation has estimated that in 2014 there were about 7 million deaths worldwide that were associated with poor local air quality. In many developed countries local air quality has improved markedly with the introduction of stringent air pollution legislation. Nevertheless, problems remain. For example, Public Health England has reported that around 5% of all deaths in over-25s were linked to air pollution in 2010. Short-term human health effects from air pollution can include irritation and inflammation of the airways, eyes and mouth, and triggering of asthma attacks in susceptible individuals. Longer-term problems are often associated with cardio-pulmonary (heart-lung) performance, but some pollutants are also associated with increased incidence of cancers.

## MORE...

For more information about the effects of poor air quality on human health, see the Healthy Air Campaign at:

http://healthyair.org.uk/

The long-range transport of air pollution from cities and industrial centres can also have regional impacts. Oxides of nitrogen ($NO_x$) and sulphur ($SO_x$) can travel hundreds of kilometres from their emission source and react with moisture in the atmosphere to create 'acid rain'. This affects trees by damaging their leaves and bark, making them more vulnerable to disease, weather and insects. Toxic amounts of aluminium and iron may also be released from soils, further damaging trees and other plants. Lake eco-systems that are exposed to acid rain may become acidic and this can kill fish eggs. At higher levels of acidity, aluminium may build up in the water and kill adult fish, which are important food sources for other animals such as birds.

We have also seen (Element 1) how global effects of air pollution – climate change and ozone depletion – have now moved to the top of the international agenda.

## THE ROLE OF AIR-QUALITY STANDARDS

Objectives and standards for the quality of the air that surrounds us form an important element of both international and national environmental policy. Objectives and standards are usually set in the form of maximum concentrations of specified pollutants that should not be exceeded in the local atmosphere. In the EU, **Directive 2008/50/EC** sets target limits for the maximum levels of a range of pollutants: fine particles, sulphur dioxide, nitrogen dioxide, lead, carbon monoxide, benzene, ozone, arsenic, cadmium, nickel and Polycyclic Aromatic Hydrocarbons (PAHs).

The emission limits that are imposed via permits on industrial installations (for example, under **Directive 2008/1/EC** on integrated pollution prevention and control), as well as other controls – for example, on vehicle engine emissions – are intended to ensure that these ambient air-quality standards are not breached.

### MORE...

The World Health Organisation (WHO) publishes a set of air-quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide. These guidelines are available at:

www.who.int/phe/health_topics/outdoorair_aqg/en

The long-range movement of air pollutants and regional impacts are the subject of other international agreements, most notably: The Geneva Convention on Long-Range Transboundary Air Pollution (and eight associated Protocols). This aims to limit and gradually reduce pollutants that can cross national boundaries. The Convention applies to the countries within the United Nations Economic Commission for Europe (UNECE) – this currently includes 56 member states across Europe and also includes Canada, the USA, Central Asian republics and Israel.

### MORE...

The *Air pollutant emission inventory guidebook* provides guidance on estimating natural and anthropogenic emissions to help in reporting emissions as required by the Geneva Convention on Long-Range Transboundary Air Pollution. It is available at:

www.eea.europa.eu/publications/emep- eea-emission-inventory-guidebook-2009

### REVISION QUESTION

1. What can be the short-term effects of human exposure to air pollution?

(Suggested Answer is at the end.)

## KEY INFORMATION

- There are various forms of air pollutants, including gases, vapours, mists, particles, smoke, dust, grit, fibres, odours and fugitive emissions.
- Fossil fuels, industrial processes and transport are all sources of air pollution.
- Common air pollutants include sulphur compounds, nitrogen compounds, halogens and their compounds, metals and Volatile Organic Compounds (VOCs).

## TYPES OF EMISSION AND THEIR HAZARDS

The contaminants that create air pollution may exist in a variety of forms: gases, vapours, mists and particles.

### Gaseous

Substances that remain in the gaseous phase at normal temperatures and pressures, such as carbon dioxide, nitrogen and ozone.

### Liquids Suspended in Air

- **Vapour**
  Gaseous state of materials that are liquid at normal temperature and pressure (e.g. steam).
- **Mist**
  Mists are fine liquid droplets suspended in the air, usually nucleated by a particle.

The health implications of liquids suspended in the air are largely dependent on the properties of the substance involved; oil or acid mists, for example, may cause irritation of the respiratory system.

### Particles

Particles consist of solid matter of all sizes, from less than 0.001 microns to greater than 100 microns (1 micron is 1 millionth of a metre).

**Note: The size of a particle is defined in terms of its aerodynamic diameter. This is a mathematical convenience and represents the diameter of a unit density sphere (water) of the same falling velocity of the particle to be measured. It is NOT the actual size of the particle.**

- **Smoke**
  Particles in the range 0.1 microns to 10 microns are seen as smoke. There are no clearly established size definitions for these particulates and different publications suggest other overlapping size bands.
- **Dust**
  A dust may consist of any size or shape of particle, crystalline or amorphous.
- **Grit**
  This is a general term for coarse, solid particulate matter and is defined as solid particles greater than 75 microns.

Particle sizes capable of being inhaled are up to 10 microns; particle sizes of less than 7 microns are capable of penetrating lung tissue.

Such particles clearly represent at least an inhalation hazard for humans and animals and, depending on their chemical nature, may lead to acute effects (such as irritation of eyes, nose, throat) or longer-term ill-health (such as asthma). Particulates, together with odours, can also represent a significant nuisance, interfering with people's enjoyment of their surroundings. We looked at some other general issues associated with airborne particulates in Element 1, when we considered the size of the environmental problem.

### Fibre

Fibres are particles given off from materials of a fibrous nature, such as wood and asbestos. Fibres will usually have an elongated shape and so cannot be compared to other particles in terms of size, as they may be very narrow but long particles.

The effects of inhalation of fibres depend largely on the type of fibre. For example, inhaling asbestos or silica can cause inflammation and scarring in the lungs – this is commonly known as asbestosis or silicosis, depending on the substance involved. Asbestos exposure may also cause changes to the lining of the chest cavity (pleura) and increase the risk of lung cancer and mesothelioma (cancer of the pleura).

## Odours

We referred to the issue of unpleasant odours in Element 1, where we noted that these can cause a nuisance to local residents.

## Fugitive Emissions

These are emissions that should not be there, i.e. they have escaped from a process in a manner that is unplanned, such as leaks from pipework or contained conveyor systems. They are often difficult to quantify owing to their dispersed nature.

## Sources of Air Pollution

### Fossil Fuels

As our population grows, so does our consumption of goods and services. Our energy consumption also increases to meet the growing demand. Currently, most of the energy we use comes from burning fossil fuels, so an increase in energy consumption tends to result in increased air pollution.

**GLOSSARY**

**FOSSIL FUEL**

A natural fuel, such as coal or gas, formed from the remains of living organisms that died millions of years ago and became fossilised beneath the Earth's surface.

The most common fossil fuels are:

- Coal (including anthracite and lignite).
- Coke.
- Petrol/gasoline.
- Diesel/DERV.
- Fuel oil/heating oil/paraffin.
- Natural gas (methane).
- LNG (Liquefied Natural Gas).
- LPG (Liquefied Petroleum Gas, propane or butane, or a mixture).

Different types of fuel have different sources - coal comes from the remains of trees and ferns, whereas natural gas and crude oil tend to come from dead marine plants. As the vegetation died it sank; the pressure above it - from layers of sediment - caused it to gradually transform; and the carbon from the plants was compressed into fossil fuel.

All fossil fuels have a very high carbon content. This carbon reacts with oxygen in the atmosphere when they are burnt. This reaction releases a large amount of carbon dioxide into the atmosphere - which makes a significant contribution to climate change. It also releases a large amount of energy in the form of heat and light.

In addition to carbon dioxide, many other contaminants can also be released into the environment - depending on the chemical make-up of the fossil fuel and any additives or impurities which may be present (i.e. lead in petrol). The most common contaminants released when fossil fuels are burned include:

| Contaminant | Description |
|---|---|
| Carbon dioxide | One of the main greenhouse gases; contributes to climate change. |
| Sulphur oxides ($SO_x$) | Contributes to the formation of acid rain. |
| Nitrogen oxides ($NO_x$) | Contributes to the formation of acid rain and city smog. |
| Particulates | Small particles of soot and ash; may cause respiratory problems. |

In addition to these common contaminants, small quantities of highly toxic substances can also be released. These can include radioactive substances and compounds of mercury and lead.

### Industrial Processes

Industrial activities almost all use fossil fuels as a power source and, as a result, contribute to air pollution.

In addition, some industrial processes release additional harmful pollutants into the atmosphere. The main industrial sources of air pollutants are:

| Industry | Air pollutants |
|---|---|
| Oil and gas refining | Particulates, sulphur oxides ($SO_x$), nitrogen oxides ($NO_x$), Volatile Organic Compounds (solvent fumes), benzene, hydrogen sulphide, hydrogen fluoride. |
| Cement manufacturing | Particulates, carbon dioxide, sulphur oxides ($SO_x$), nitrogen oxides ($NO_x$), hydrogen chloride, benzene, toluene, xylene. |
| Metal smelting and refining | Particulates, carbon dioxide, sulphur oxides ($SO_x$), nitrogen oxides ($NO_x$), hydrocarbons, acid gases. |
| Pulp and paper manufacturing | Particulates, Volatile Organic Compounds (solvent fumes), chloroform, formaldehyde, ammonia. |
| Chemical production | Volatile Organic Compounds (solvent fumes), acid gases. |
| Waste incineration | Particulates, carbon dioxide, sulphur oxides ($SO_x$), nitrogen oxides ($NO_x$), hydrogen chloride, hydrogen fluoride. |

### Transport

Motorised road transport has grown almost exponentially over the last 50 years. Around half of the world's oil production is now consumed by cars, trucks and buses. There has been a similar expansion of air travel, which also depends entirely on fossil fuel.

As a result, fossil-fuel combustion for transportation is now a major source of air pollution, especially poor air quality in city centres. It has been estimated that in industrialised countries the transport sector accounts for 70-90% of all carbon monoxide emissions, 60% of particulate emissions and 40-70% of nitrogen oxide ($NO_x$) emissions. Until quite recently, the compound tetraethyl lead was widely used as an additive in petrol and this was the source of high levels of lead in the atmosphere and urban soils which has been linked with neurotoxic effects, especially in children.

## COMMON POLLUTANTS

### Sulphur Compounds

#### TOPIC FOCUS

**Sulphur Compounds**

Man-made sources:

- Combustion of fossil fuels, e.g. coal and oil. Combustion may be in industrial processes, domestic fires, boilers and vehicles.

Effects:

- Acid rain.
- Irritant to the eyes, nose and lungs. Irritation to the lungs can cause respiratory problems.

Compounds of sulphur that form atmospheric pollutants include:

- Sulphur dioxide ($SO_2$).
- Sulphur trioxide ($SO_3$).
- Sulphuric acid.
- Sulphate salts.
- Hydrogen sulphide.

Much of the atmospheric sulphur comes from natural sources such as volcanic activity, decaying organic matter, phytoplankton (vegetable plankton) and sulphur springs. These natural sources may account for up to half the total volume of current atmospheric sulphur. Man-made sources will account for the remaining atmospheric sulphur.

### Nitrogen Compounds

#### TOPIC FOCUS

**Nitrogen Compounds**

Man-made sources:

- Combustion of fossil fuels, e.g. coal and oil. Combustion may be in industrial processes, domestic fires, boilers and vehicles.

Effects:

- Acid rain.
- Depletion of the ozone layer.
- Generation of photochemical smogs.

The main compounds of nitrogen in the atmosphere are:

- Nitric oxide (NO).
- Nitrogen dioxide ($NO_2$).

Nitrogen is a commonly occurring natural element and indeed makes up almost 80% of the atmosphere. The main man-made sources of oxides of nitrogen are similar to those for sulphur, being mainly combustion processes. Little nitric oxide (NO) is produced at room temperature, but with increasing temperature more NO is produced.

While NO has no known adverse health effects, it is slowly converted into $NO_2$ in the atmosphere, and $NO_2$ is known to be toxic. $NO_2$ forms secondary pollutants, such as tropospheric ozone ($O_3$), which is a strong oxidising agent and highly reactive.

### Halogens and their Compounds

Halogens are a group of elements such as fluorine, chlorine, bromine and iodine. Fluorine and chlorine are gases in their natural state, while bromine is a liquid and iodine a solid. They are highly reactive elements and can therefore be harmful, or lethal to biological organisms in sufficient quantities. Halogens occur in numerous compounds.

## TOPIC FOCUS

**Halogens and their Compounds**

Man-made sources:

- Disinfectants in drinking/swimming water (chlorine, bromine).
- Toothpaste additive (fluorine).
- Treatment of materials against fire damage, as they are fire-retardant (e.g. halons – bromine).
- Chlorofluorocarbons (CFCs) (see Element 1).
- Pesticides, herbicides and fungicides (e.g. DDT - chlorine).
- Dyes, soaps and medicines (iodine).

Effects:

- Attack inert materials such as glass (particularly fluorine).
- Burns the skin and a respiratory irritant.
- Fatal in high doses (particularly chlorine).
- Ozone depletion.

### Metals

The main metal pollutant in the air is from lead that was added to petrol to improve engine performance. When leaded petrol is burned, lead is emitted from the exhaust, and concern has focused on health effects. Lead emissions from road vehicles are falling as a result of the use of unleaded petrol.

## TOPIC FOCUS

**Lead**

Man-made sources:

- Leaded fuel (we now use unleaded).
- Lead-based paints.
- Lead water pipes.
- Metal industry.

Effects:

- High levels - nausea, vomiting, convulsions, death.
- Low levels over long periods:
  - Irritability, sleeplessness, fatigue.
  - Constipation, headache, loss of appetite.
  - Anaemia.
  - Damage to the brain and nervous system.
  - Kidney damage.

### Volatile Organic Compounds (VOCs)

VOCs are gases emitted from certain solids and liquids. They easily vaporise at room temperature. There are many different VOCs; examples include benzene, toluene and Polycyclic Aromatic Hydrocarbons (PAHs).

## TOPIC FOCUS

**Volatile Organic Compounds (VOCs)**

Man-made sources:

- Exhaust fumes.
- Cigarette smoke.
- Synthetic materials.
- Household chemicals.
- Paints.
- Glues and adhesives.

Effects:

- Involved in formation of ground-level ozone and photochemical smog.
- Eye, nose and throat irritation.
- Dizziness and memory impairment.
- Some VOCs cause cancer.

## REVISION QUESTION

2. Define the terms 'vapour', 'mist' and 'fume'.

(Suggested Answer is at the end.)

## KEY INFORMATION

- There is a control hierarchy to reduce emissions, with elimination being the preferred option, followed by minimisation and then finally rendering harmless, where the other options are not practicable.
- Technical solutions to control **particulate** emissions to the air are filtration, separation and wet scrubbers.
- Technical solutions to control **gaseous** emissions to the air are adsorption and water walls.

Industrial air-pollution control encompasses the design, process engineering and abatement techniques necessary to eliminate, reduce or render harmless the emission of contaminants into the atmosphere. The most cost-effective and efficient methods are those incorporated into the process design to reduce the total mass of contaminants in the waste stream. The engineering devices should be supplemented by management techniques, i.e. procedures, information, instruction and training.

### CONTROL HIERARCHY

The control hierarchy describes a system of controls of different effectiveness. For instance, if a pollutant can be **eliminated** then there is no need to have procedures in place to minimise it, or render it harmless before exhausting to atmosphere. If it can be **minimised** then there is less to deal with. If neither of these are possible, then we are left with the **render harmless** option. One problem with this is that the harmful substance is still in use and if it escapes through failures in process or equipment it can still cause harm.

## TOPIC FOCUS

**Control Hierarchy**

**Eliminate:**

- Replace solvent-based chemicals with water-based chemicals, e.g. paints.
- Replace chemical process with mechanical process. Mechanically-generated particles are generally larger than those produced through a chemical process and therefore easier to collect.
- Replace halogenated products with non-halogenated products. When CFCs were banned, they were replaced with products such as propane and isobutene as alternative propellants (or use pump-action sprays, which remove the need for any propellant).

**Minimise:**

- This has been achieved in the motor industry through the use of improved technology, such as engine management systems and fuel injection. Modern cars do significantly more miles per gallon/litre of fuel than older cars, when we compare similar engine sizes. They are also more powerful, so both fuel economy and performance have improved, yet emissions are reduced.

**Render harmless:**

- The techniques described in the Examples of Technology subsection of this element either minimise pollutants, or render them harmless before they are emitted to atmosphere.

## EXAMPLES OF TECHNOLOGY

There are many techniques available to control pollution to the atmosphere and we discuss some of the main ones below. The choice of technique will depend on a number of variables, such as the:

- type and volume of pollutant to be controlled; and
- environment in which the process takes place.

## Filtration

Fabric filters remove dust from a gas stream by passing it through a fabric. The fabric must allow air to pass through it and remove the dust particles from the air. The layer of dust which accumulates on the fabric surface is called the filter cake.

Fabric filters are generally more efficient at removing smaller particles from air streams than cyclones (see later). Consequently, cyclones are often used as first-stage air-cleaning devices to remove the larger particles from the air stream before it is passed into a fabric-filter unit.

## Fabric-Filter Types

Fabric filters are normally designed with the fabric forming cylinders or bags. Usually, there are several filter bags or filter elements grouped together in an enclosure; the whole cleaning device is called a 'bag house' or 'bag filter plant'. Types of bag filter plant are differentiated by the mechanism used to remove the filter cake from the surface of the bag.

There are three commonly used mechanisms:

- **Mechanically Shaken**

  In the early 1890s, bag-shaped filters were used and these were shaken by hand to remove the filter cake. Modern bag-filter plants employ mechanical shaking devices to vibrate the bag at frequencies between 10 and 100 cycles per second, for a few minutes. Generally, the bag is open at the bottom and closed at the top. The dust-laden air enters the bag at the bottom and passes up and through the bag to leave the filter plant through vents at the top. The filter cake therefore accumulates on the inner surface of the bag.

  The cleaning cycle is operated at regular intervals to remove the filter cake before the airflow through the bag is stopped, and a slight reverse airflow is sometimes introduced to aid cleaning. The bags are shaken and the released dust is collected in hoppers at the base of the plant.

  The mechanical shaking of the bags induces friction and stresses the fabric, so the material of the filters must be chosen to tolerate this.

- **Reverse Airflow**

  This cleaning technique involves passing cleaned air through the bags in the opposite direction to the normal operating direction. In high-temperature operations the cleaned air is re-circulated rather than using colder ambient air, which reduces the thermal stresses in the plant and prevents condensation.

  During the cleaning cycle, the normal airflow is diverted and a reverse air current applied to the outside of the bag. This change in pressure initially causes the bag to deform and the filter cake is dislodged and falls into a hopper. This method of cleaning involves less mechanical stress to the bags and so the strength of the fabric material is not so crucial.

- **Pulse-Jet Systems**

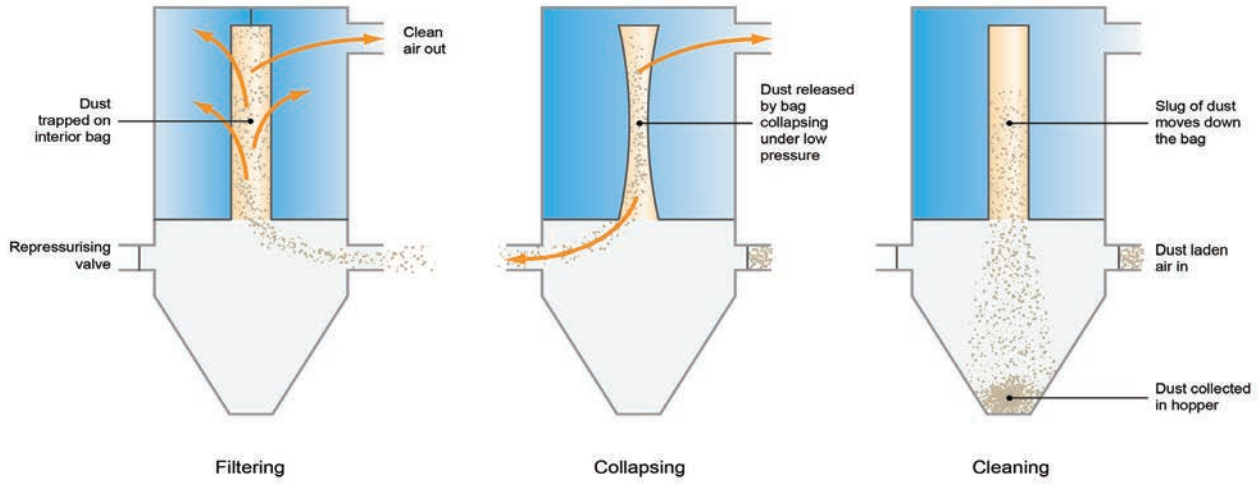
  Pulse-jet bag-filter plants employ jets of compressed air to remove the filter cake. In these plants, the bag-filter elements are closed at the bottom and open at the top. The dust-laden air passes from the outside of the bag to the inside and up to vents at the top of the plant. The filter cake forms on the outside of the bag. To prevent the bags collapsing in normal operation, they are supported on the inside by metal rings or cages.

  During the cleaning cycle, the airflow to the bags is redirected and air, from compressed air nozzles at the open tops of the bags, is directed into the bags. This positive pressure slightly inflates the bags and the deformation and outward flow of air dislodges the filter cake. The dislodged dust falls into a hopper and is removed from the plant.

## Bag Filter Efficiency

The method of measuring efficiencies involves measuring the particle concentrations in different size ranges and expressing efficiency as the percentage of mass concentration retained by the plant in each size range.

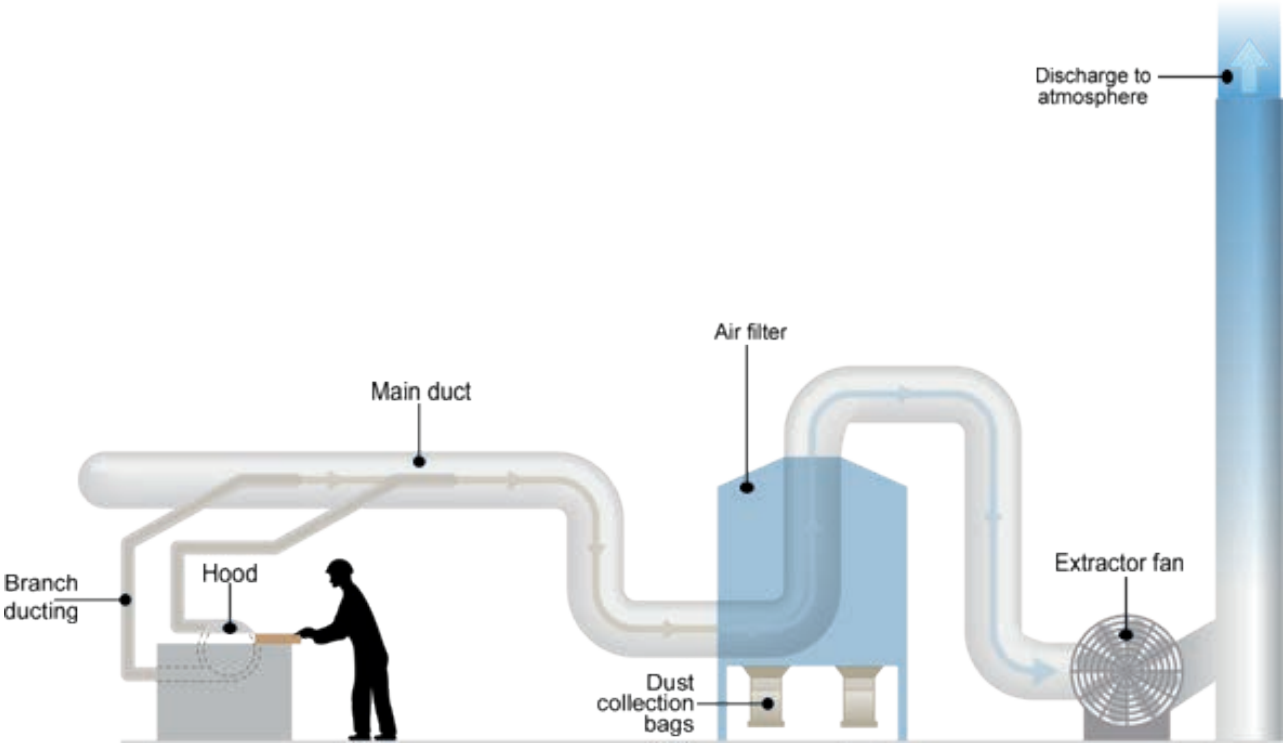
Specific characteristics are important in designing plants to deal with specific situations. The parameters include the gas-to-cloth ratio for particular materials. This is the measure of gas flow through a unit area of material. However, this measure considers only the material and not the filter cake. There are various theoretical equations for pressure drop across a porous bed and they are applied to material and filter-cake combinations to determine the appropriate fan sizes and cleaning cycle frequencies.




Bag filter reverse-air cleaning

## Local Exhaust Ventilation (LEV)

The main object of LEV is to extract the flow of air away from a work process using hazardous airborne substances. The air is cleaned, often with a bag filter, before exhausting it to the outside atmosphere.




A typical LEV system extracting sawdust from a bench-mounted circular saw

## Separation Technology

### Gravity Separators

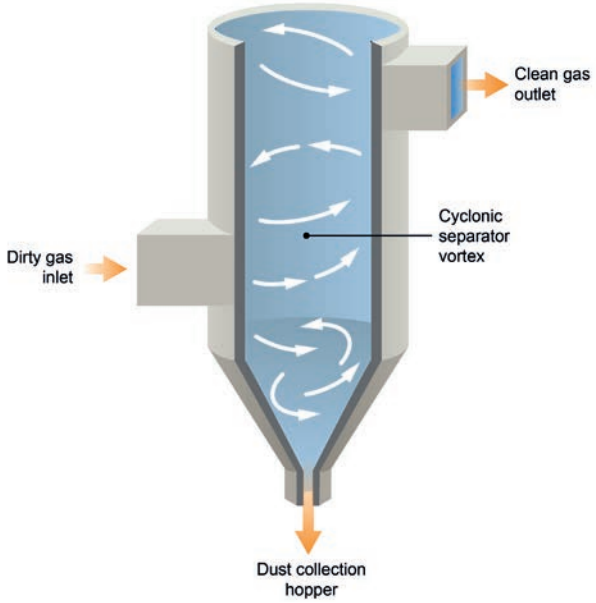
These devices use the force of gravity as the primary method of separation. A settling chamber reduces airflow speed as much as possible for as long as possible. Grit and large dust particles collect in hoppers beneath the chamber. This may be used as a first stage of more thorough cleaning, e.g. to settle fly ash in a power station or Municipal Solid Waste (MSW) incinerator.

Cyclones operate by causing the airflow to change direction rapidly into a spiral, throwing the particles out of the air stream toward the walls of the device. The particles then fall down to the bottom of the device for collection. Cyclones are most efficient for large dense particulates; smaller, less dense particulates may be carried on through the cyclone.

Cyclones are used primarily for the following functions:

- Product recovery, e.g. wood dust.
- First-stage air-stream cleaning.
- Droplet removal.

Single cyclones have no moving parts, so the running costs and maintenance requirements are low. However, their efficiencies are much lower than those of fabric filters or electrostatic precipitators (see below) and, generally, they are not suitable for achieving current air-emission standards.




Cyclone schematic

Cyclones may be arranged in groups and operated in parallel.

### Electrostatic or Magnetic Separators

- **Principles**

  An electrostatic precipitator (ESP) is a particulate and droplet control device which uses electrical forces to remove particles from a dust-laden air stream. An area of ionised air molecules is established, usually around a wire, by maintaining the wire at a very high voltage, typically 20,000 to 100,000 volts. This region of ionised air molecules is called a corona. As dust particles flow through the corona, they collect the ions, and then the dust particles themselves become charged. Small particles, around one micron, may collect tens of thousands of ions. A plate, called the collector plate, is maintained at the opposite electrical polarity to the wire and the particles, so that the charged particles migrate toward the plate.

**GLOSSARY**

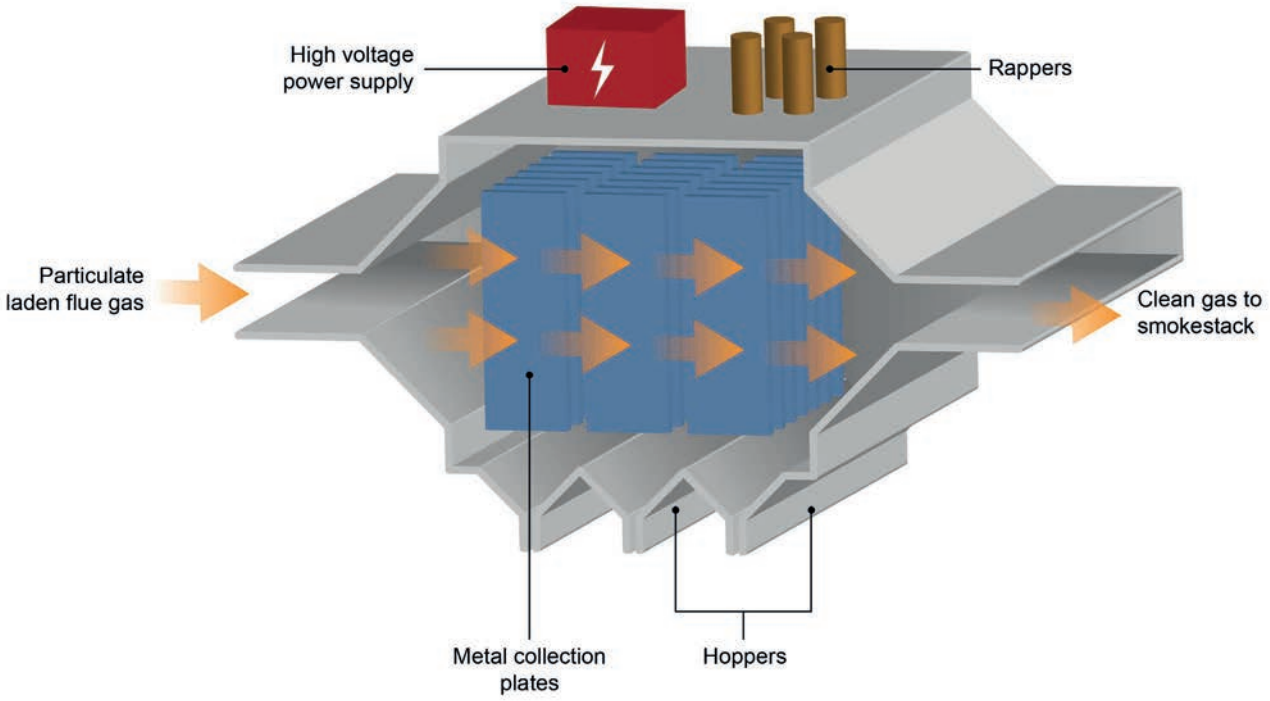
**IONISED MOLECULE**

Physically converted into an ion by adding or removing a charged particle such as an electron.

For example, Sodium (Na) is a neutral atom (it is neither negatively nor positively charged). When it combines with Chlorine (Cl) it loses an electron and becomes positively charged ($Na^+$). The Chlorine gains the electron and becomes negatively charged ($Cl^-$). They are ionised and combine together to form NaCl (common salt).

Electrostatic precipitators are normally arranged with a series of wires between rows of plates so that as the particles pass each wire, they collect more of a charge and drift progressively towards the plates. The removal of dust from the plates is often achieved by rapping the top of the plates mechanically, using a hammer or piston. The released dust then drops or slides down the plate into a hopper. During this process, approximately 10% of the dust may re-enter the air stream. Most of this dust is recaptured, but dust released at the outlet of the device will escape into the exhaust air stream.

The dust deposited on the plates is not a solid cake, as in a bag-filter plant, but a fragile deposit. Therefore, there may be re-entry of the dust by the airflow over the plates. To prevent this, baffles are often included to reduce airflow over the plate surface.



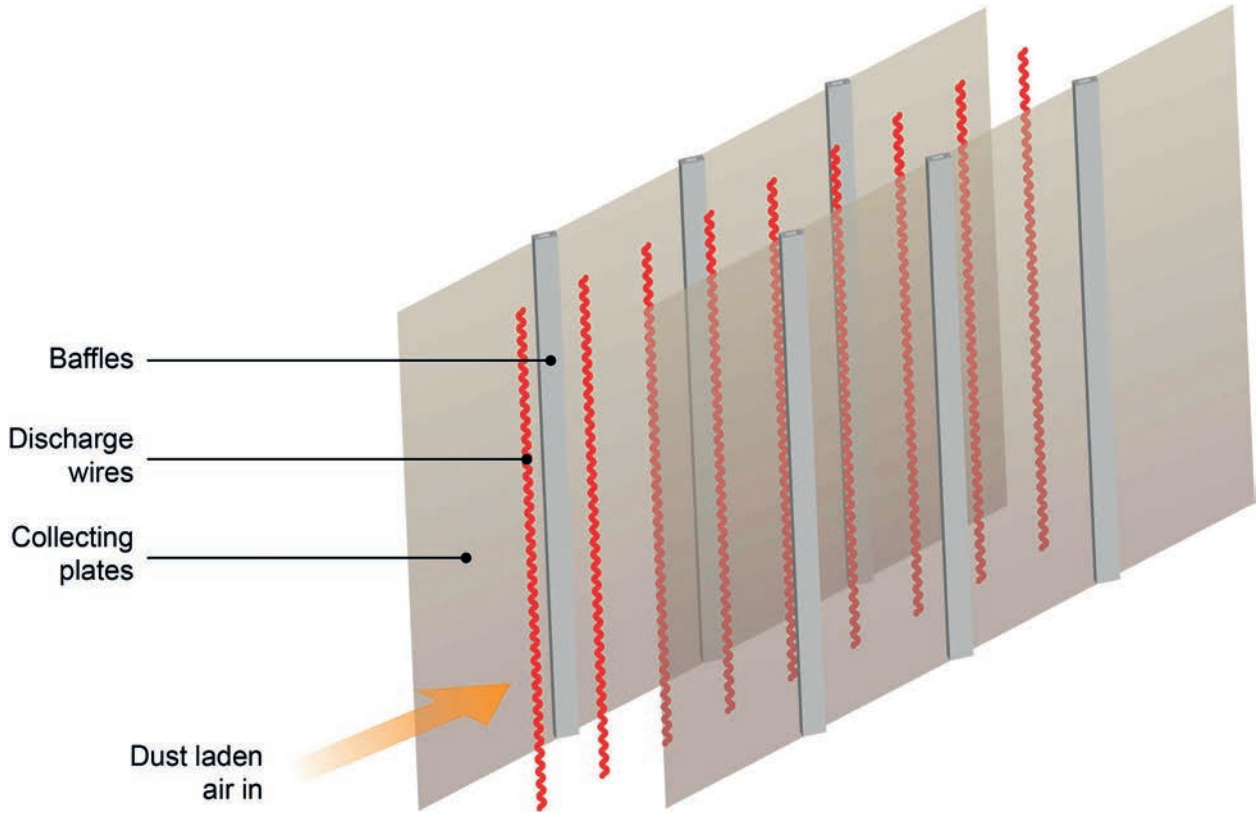

Electrostatic precipitator (plate-wire)

## TOPIC FOCUS

**Types of Electrostatic Precipitator**

There are four main types of precipitator:

- **Plate-Wire Precipitators**
  - As described.
  - The most common type.
  - Used in a wide variety of industrial applications, e.g. coal-fired boilers, cement kilns, solid-waste incinerators, paper-mill recovery boilers, petroleum refining and catalytic cracking units, sinter plants, basic oxygen furnaces, open-hearth furnaces, electric-arc furnaces, coke-oven batteries and glass furnaces.
- **Flat Plate Precipitators**
  - Used for smaller applications.
  - Use a central plate rather than a wire.
  - Since a corona cannot be generated on flat plates, needle-like electrodes are located on the leading and trailing edges of the central plates.
  - Flat plate ESPs have applications for small (less than one micron) particles with high resistivities.
- **Tubular Precipitators**
  - Early ESPs were tubular, with the discharge wire running up the centre of the tube. To accommodate higher airflows, the tubes were often arranged in bundles.
  - The tubes may be formed as a circular, square or hexagonal honeycomb and can be tightly sealed to prevent leaks of material.
  - Most often used in sulphuric-acid plants, coke ovens, and iron and steel plants.
  - Often also used to recover valuable materials, or to control the release of hazardous material.
- **Water-Irrigated Precipitators**
  - May be of any of the design types discussed above, but with walls washed with water rather than the dry dust rapped from the surface.
  - Water flow may be continuous or intermittent, with the sludge collected in a sump below the plates.
  - This method generates slurry, which is more difficult and expensive to dispose of than a dry dust deposit.




Flat plate electrostatic precipitator

- **Typical Applications**

  Electrostatic precipitators are often used as the final stages in an air-cleaning system. Where there are high dust loadings with large particles, a cyclone is often used as a first-stage cleaning device to remove the coarse, or large particles from the air stream.

## Wet Scrubbers

- **Principles**

  Wet scrubbing techniques are used to remove particulates from waste gas streams. Gases will also be removed and the mechanisms involved are similar to those employed in absorption devices, such as packed columns, whose main function is to remove soluble gases.

  Wet scrubbing techniques are normally employed where the:

  – Contaminant cannot be removed easily in a dry form.
  – Waste gas stream contains both particulates and soluble gases.
  – Particulates to be removed are soluble or wettable; they would adhere to the inner surfaces of a cyclone or bag-filter plant and clog it.
  – Contaminant will undergo some subsequent wet process, such as sedimentation, wet separation, or neutralisation.
  – Pollution control system must be compact.
  – Particulates may ignite, or explode if collected in a dry form.

Wet scrubbing is used to:

– Control sticky emissions, which may block filter-type collectors.
– Handle waste gas streams containing both particulates and gases.
– Recover soluble dusts and powders.
– Remove metallic dusts, such as aluminium, which may explode if handled dry.

The principle of all wet scrubbers is that water droplets are generated within the device and particles are captured within the droplets. The droplets are then removed from the air stream, which is now clean. The droplets are collected as contaminated water and transported out of the device for treatment or disposal. To aid the removal of contaminants, the water droplets may be acidified (made more acidic), or basified (made more alkaline).

The methods for bringing the water droplets in contact with the dust-laden air include:

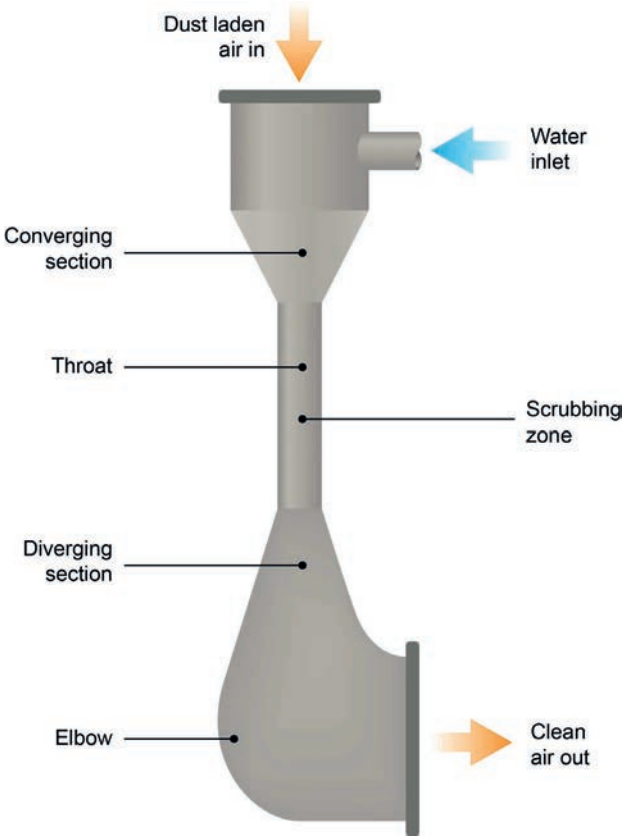
– Injecting water directly into the air stream and mechanically shearing the water into droplets.
– Spraying the water into the gas stream.
– Injecting water onto a spinning disc or fan.

Different scrubber designs use different techniques, or combinations of techniques.

## TOPIC FOCUS

There are five basic types of **scrubber design**:

- **Venturi Scrubbers**
  These devices create atomised droplets by injecting water into the gas stream before accelerating the water through a high-velocity zone called a venturi throat. The water and the gas stream are then released into a low-pressure area called the diverging section. The turbulence in the venturi throat breaks the water into tiny droplets and particle capture occurs toward the end of the venturi throat and at the beginning of the diverging section.
- **Mechanically-Aided Scrubbers**
  These devices use spinning discs or fans to generate water droplets.
- **Pump-Aided Scrubbers**
  These devices spray the water as droplets into the gas stream.
- **Wetted Filter Scrubbers**
  These devices use a combination of water spray and a filtration element. Particles are captured by water droplets, as described previously. However, particles may also impact temporarily on the elements of the filter to be washed off by a film of water.
- **Tray or Sieve Scrubbers**
  Tray or sieve-type wet scrubbers have small holes in trays that accelerate the gas stream. Water is piped onto the trays to form a shallow layer of water. The airflow through the holes creates a froth, which assists in capturing particles.



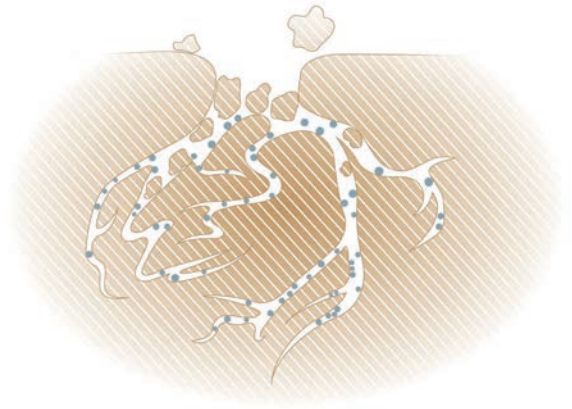

Simple venturi scrubber

- **Droplet Removal**
  Many scrubbers use cyclonic separators or cyclones to remove droplets. Others use **chevron** droplet eliminators for either vertical or horizontal gas flow. Shaped like curved and parallel blades, the chevron introduces a surface against which droplets impact and accumulate as water and then drain off. The solids that accumulate on the surface are periodically washed off using water sprays.

  For finer droplets, mist eliminators comprising a fine metal mesh are often used. A layer of wire mesh is introduced in the final duct and the mist accumulates on it and drops off. The mesh mist eliminators are also spray-washed periodically to remove any particulate build-up.

## Adsorption

The process of adsorption involves the retention of a gas or vapour molecule on the surface of a particle or droplet. The phenomenon is essentially a surface reaction, as opposed to absorption, which involves the complete encapsulation of a molecule, which is then dissolved in a liquid droplet. Some solids with many pores and crevices present extremely large surface areas to gases and so are the most appropriate adsorbents. These include activated carbon, activated alumina and silica gel.



Adsorption on a solid with many pores

Adsorbents are selected depending on the type and quantity of contaminant you wish to remove:

- **Activated Carbon**
  Activated carbon is charcoal that has been heated in the absence of air. At one time, wood was heated to produce charcoal, but later developments include the use of coal, coconut shells, peat and other substances.
  After heating, the carbon is activated to remove the volatile components. In the case of coal, high-temperature steam is used. However, zinc chloride, magnesium chloride, calcium chloride and phosphoric acid have also been used as activating agents.
- **Activated Alumina**
  Activated alumina and hydrated aluminium oxide is produced by special heat treatment of aluminium ore or bauxite. Activated alumina is mainly used for drying gases under pressure, as it has an affinity for water.
- **Silica Gel**
  Silica gel is an amorphous form of silica, derived from the interaction of sodium silicate and sulphuric acid. It is often used as an adsorbent where activated carbon is not appropriate. Like alumina, silica gel has an affinity for water.

## Operational Mechanisms

Adsorption systems are designed either to:

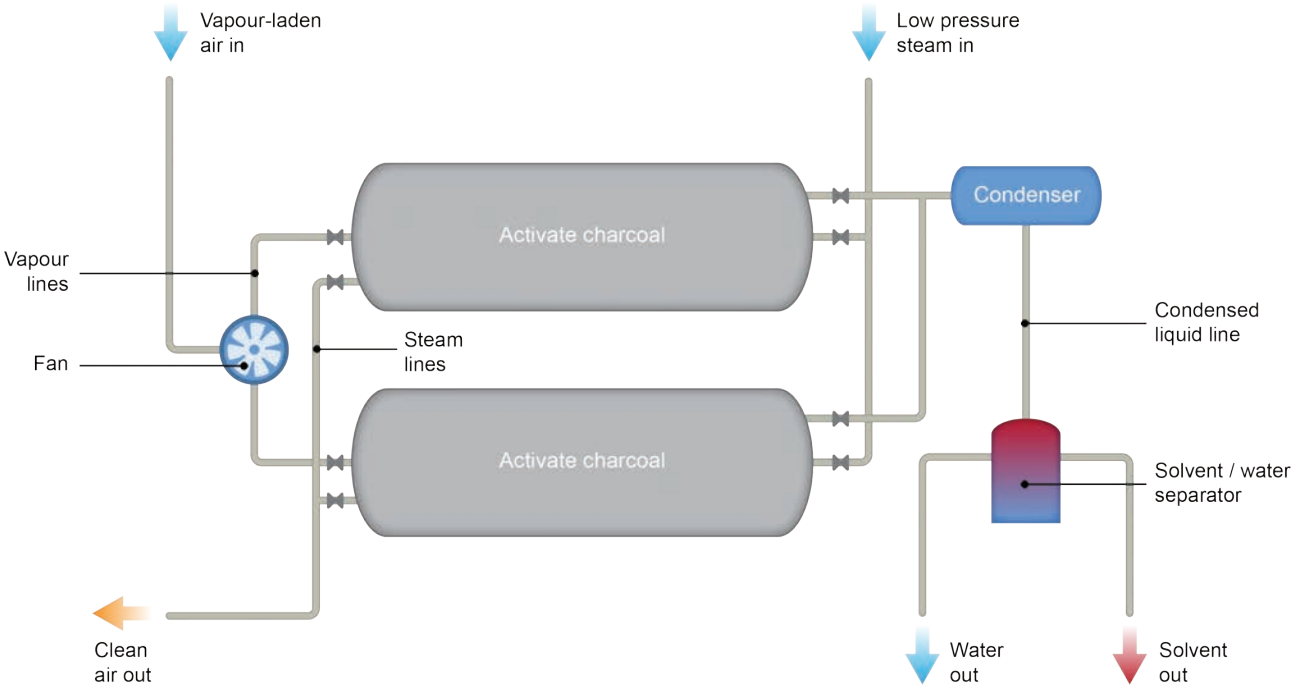
- remove pollutant gases and vapours from air streams, to prevent the emission of those pollutants to atmosphere; or
- collect those vapours to return them to the process.

In either case, there are four phases in the process:

- Contact between the polluted air stream and the adsorbent under conditions that allow adsorption of the pollutant.
- Removal of the cleaned air stream from the adsorbent.
- Regeneration of the adsorbent to recover the pollutants and re-use the adsorbent.
- Re-use or disposal of the pollutant.

The adsorbent most often used is activated carbon.

- **Static-Bed System**
  In simple systems, granulated activated carbon is held in a vertical column and solvent-laden air is passed down through the column. The solvent is progressively adsorbed on the carbon and the cleaned air passes out of the column to the atmosphere. After a predetermined period, set to ensure that the carbon is not completely saturated with solvent, the airflow through the column is shut off and the carbon is regenerated by lowering the gas pressure, or by increasing the temperature. This desorbs (releases) the contaminants, which can be recovered.
  After the solvent is steam-stripped, the carbon beds are hot and saturated with water. The beds are normally opened and air-dried, allowing the water to evaporate to atmosphere. Multiple systems are common where two or more columns are used. This allows some columns to be in the adsorption part of the cycle, while others are in the regeneration part of the cycle.




Simple activated carbon solvent recovery system

- **Rotary-Bed Systems**

  In order to ensure more efficient use of the carbon bed, continuous rotary-bed systems have been developed. These consist of a rotating drum containing activated carbon. The drum has a hollow central core along the axis of rotation, and the space between the inner and outer walls of the drum is divided into radial sections. Vapour-laden air enters the drum in one section, at one end of the drum. It then travels along the length of the section and the vapour is adsorbed in the carbon. The cleaned air leaves through the central core from the far end of the drum.

  Once that section is saturated with vapour, the drum rotates to the next section. At another vapour-saturated section of the drum, steam is pumped up a pipe in the central core, to enter the section at the far end of the drum. The steam passes through the vapour-saturated carbon to exit as a steam and solvent mixture at the front end of the drum. Therefore, there is always adsorption and regeneration within the drum.

- **Process Controls**

  Before a carbon-bed adsorption system is considered or designed, careful consideration should be given to modifying existing processes and procedures to reduce the quantities of VOCs in the exhaust air streams:

  – Consider whether the use of the solvent is necessary, or whether a water-based system or detergent degreasing system could be used.
  – Consider the substitution of the solvent for a lower volatility solvent, or a less toxic solvent, or one with a lower environmental impact.
  – Minimise the ventilation rates and volumes in the process to reduce evaporation rates.
  – Establish working procedures for effective use of the system and train workers to comply with them.
  – Provide well-designed LEV systems with hoods and tank enclosures.
  – Cover tanks when not in use.
  – Perform solvent spraying in a vapour zone. Do not use compressed-air drying techniques.
  – Do not direct ventilation fans onto solvent baths, containers, or uncontrolled drying areas.

- **Maintenance and Operation**

  The surface area of carbon granules must be protected against dirt and other particulates entering the bed. It is common to have a fabric filter, or bag filter as a primary air-cleaning device located upstream of the carbon bed. Some solvents entering the adsorption bed will chemically react and progressively reduce the working surface area of the carbon. Such substances must not be allowed to enter the bed.

  Such funding may be difficult to obtain in developing countries.

  Many LEV systems have been introduced to satisfy occupational hygiene requirements. Poor hood and enclosure design and leaking ducts have often been compensated for by higher ventilation velocities and volumes, which are not consistent with efficient final air-cleaning characteristics. Careful consideration should be given to improved design characteristics, which deliver lower ventilation velocities and volumes. This will lead to:

  – Lower space-heating energy requirements.
  – More efficient final air cleaning.
  – Lower atmospheric emissions.
  – Lower fan and system maintenance costs.

## Water Walls

Water can be used to suppress dust and prevent it escaping from a confined area. This technique is commonly used in construction and demolition, where large amounts of dust can be generated and therefore need to be controlled. There are two common methods:

- Rain guns – used to spray water over stockpiles or buildings being demolished and keep material damp but not wet. This reduces the amount of dust created by the break-up of the building material. The guns can be either static or mounted on vehicles such as loading shovels so they suppress dust as material is moved around a site.
- Perimeter systems – create a curtain of fine water particles that can cover a large area where activities may create dust.

With both systems the design of the nozzles is critical to avoid using excessive volumes of water and creating run-off that then needs to be controlled. If designed and installed correctly there should be little, if any, run-off as the particle size of the water droplets is such that they encourage dust particles to bind together and therefore drop out of suspension in the atmosphere.

## Maintenance of Equipment

Any equipment that is used will need to be subject to planned preventative maintenance. This will ensure that it continues to carry out the abatement of air pollutants to the initially planned level. It is important, therefore, that funding for maintenance is provided to ensure the devices' continuing effectiveness.

Poor maintenance of pollution abatement and other equipment is an important cause of process failure and pollution incidents in developing economies, often because of a lack of proper funding. It should also be recognised that certain environments present significant logistical or practical challenges in undertaking regular planned maintenance – for example, on offshore oil and gas installations, or facilities located in Arctic or desert environments.

## TOPIC FOCUS

Summary of Abatement Technologies

| Abatement Technology | Uses | Mode of Operation |
|---|---|---|
| Fabric Filters | Removal of particulates – efficient for small particles. | Dust-laden air is passed through a filter before being extracted to the outside. The dust is caught on the filter and removed by mechanical means, reverse airflow, or pulse jet systems. |
| Gravity Separators | Removal of particulates:<br>• Only used for larger particles.<br>• Often used before a fabric filter. | Dust-laden air is passed through a settling chamber at a lower air speed. Grit and dust drops and is collected in a hopper below the chamber. |
| Cyclones | • Removal of particulates.<br>• Only used for larger particles.<br>• Often used before a fabric filter. | The dust-laden air is rapidly forced into a spiral, causing particles to fall to the bottom of the device for collection. |
| Electrostatic Precipitators | Removal of particulates – efficient for small particles. | Dust particles are electrically charged and attracted to a plate of opposite charge. The collected dust on the plate can then be removed mechanically. |
| Wet Scrubbers | Removal of particles and gases. | The particles or gases are brought in contact with water droplets (or other liquids, if collecting some gases). The particles are captured in the droplets and removed as a sludge. |
| Adsorption | Particularly useful for removal of VOCs. | Activated carbon is the most commonly used adsorbent. The contaminated dust is passed over the activated carbon and 'captured' within the surface pores (but doesn't chemically react). The application of heat will cause the VOCs to be released and captured. The activated carbon can then be reactivated and used again. |
| Water Walls | Usually used for the suppression of dust. | Water may be sprayed over stockpiles of dusty materials to prevent them becoming airborne, or a curtain of fine water may be placed around an area where dusty work is being undertaken. |

## REVISION QUESTIONS

3. List the three options that make up the control hierarchy and give an example of each.
4. What is wet scrubbing and when might it be used?
5. What is the objective of Local Exhaust Ventilation?

(Suggested Answers are at the end.)

## SUMMARY

This element has dealt with the control of emissions to air.

In particular, this element has:

- Outlined how poor air quality can have detrimental effects on human health (e.g. irritation and inflammation of the airways) and can affect the general environment (e.g. acid rain).
- Explained that targets can be set for the maximum acceptable airborne contamination to be achieved within a specified timescale.
- Outlined different sources of air pollution, including fossil fuels, industrial processes and transport.
- Described common pollutants of the atmosphere, including:
  - Sulphur compounds (e.g. acid rain).
  - Nitrogen compounds (e.g. photochemical smogs).
  - Halogens and their compounds (e.g. ozone depletion).
  - Volatile organic compounds (e.g. formation of ground-level ozone).
- Explained the control hierarchy relating to emissions to air, which consists of:
  - Eliminate, e.g. replace solvent-based paints with water-based ones.
  - Minimise, e.g. improved technology.
  - Render harmless, e.g. use of filtration, etc.
- Outlined how the choice of technique used to control pollution to the atmosphere will depend on a number of variables, such as type and volume of pollutant and the environment in which the process takes place. Available techniques include:
  - Various types of filtration (e.g. bag filters).
  - Separation techniques (e.g. gravity separators).
  - Wet scrubbers.
  - Adsorption.
  - Water wall.


## QUESTION

(a) **Identify FOUR** air pollutants that may have a significant environmental impact. (4)
(b) **Identify ONE** typical activity that could lead to the release of each air pollutant identified in (a). (4)

### APPROACHING THE QUESTION

- Read the question.
- Consider the marks available. In this case, there are eight marks available so you should spend a maximum of nine minutes answering the question and provide eight pieces of significantly different information (four for (a) and four for (b)). (**Note**: as both sub parts are 'Identify' questions you may find you spend fewer than nine minutes on this question.)
- Highlight the key words. In this case, they would include:
  (a) Identify, FOUR, common air pollutants.
  (b) Identify, ONE typical activity, EACH air pollutant identified in (a).
- Read the question again.
- Both (a) and (b) are 'Identify' questions, requiring a short answer, so do not require a plan.

### SUGGESTED ANSWER

Now you have finished your answer, read the suggested answer below and compare it to your answer.

(a) Any four from particulate matter (e.g. dust, smoke, grit), carbon dioxide, oxides of sulphur, oxides of nitrogen, methane, CFCs, solvents.
(b) One activity each for four of the following:
  – Particulate matter: quarries, construction sites, fine particles produced in combustion.
  – Carbon dioxide: combustion of fossil fuels.
  – Oxides of sulphur: burning of fossil fuels (mainly coal and diesel), metal processing.
  – Oxides of nitrogen: fossil-fuel combustion, e.g. vehicle exhausts.
  – Methane: landfill and other anaerobic processes.
  – CFCs: destruction of older refrigeration units.
  – Solvents: paint/coatings manufacture and use, degreasing.

# CONTROL OF CONTAMINATION OF WATER SOURCES

ELEMENT 5

## LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Outline the importance of the quality of water for life.
2. Outline the main sources of water pollution.
3. Outline the main control measures that are available to reduce contamination of water sources.

# Contents

## KEY INFORMATION

- Drinking water is sourced from groundwater, reservoirs and rivers. It is treated to provide an adequate and continuous supply of water free from pathogens and other undesirable characteristics.
- Water is continuously transported around the water cycle, in either liquid, vapour or ice.
- It is important we protect groundwater and rivers as they are an essential resource.
- Water conservation is important as less than 1% of the water on the planet is available for use.
- Pollution and over-abstraction of water and groundwater can affect human health and impact ecosystems.

Water is essential for life:

- We need clean, fresh water to drink and for washing.
- Our food crops need water for irrigation.
- Rivers, lakes and the seas provide habitats for wildlife and provide us with food and places of recreation.

## WHAT IS MEANT BY SAFE DRINKING WATER

Safe drinking water is defined by the World Health Organisation (WHO) as being: "water that does not represent any significant risk over a lifetime of consumption, including different sensitivities that may occur between life stages".

Waterborne diseases, transmitted by poor-quality drinking water and lack of sanitation, are among the most important health challenges facing mankind. The World Health Organisation estimates that:

- Some 1.6 million people – mostly children under the age of 5 – die every year from diarrhoeal diseases (e.g. cholera).
- More than 100 million people suffer from intestinal helminth (parasitic worm) infections.

As well as carrying a large number of pathogens, drinking water may have a range of other undesirable characteristics:

- Unpleasant colour, e.g. due to dissolved organic matter.
- Turbidity, e.g. caused by suspended mineral or organic matter.
- Unpleasant taste and smell, e.g. due to sewage contamination.
- High mineral content, e.g. minerals absorbed from contact with soil, such as calcium or magnesium sulphates, that cause "hardness".

## GLOSSARY

### PATHOGENS

Disease-causing organisms, such as bacteria and parasites that cause diseases such as cholera, typhoid, dysentery, bilharzias and hookworm.

Safe drinking water is water with microbial, chemical and physical characteristics that meet WHO guidelines, or national standards on drinking-water quality.

Water treatment is required to produce an adequate and continuous supply of safe drinking water. In general terms this means water that is:

- Free from pathogens.
- Free from harmful mineral content.
- Clear, i.e. is not turbid or coloured.
- Palatable, i.e. has no unpleasant taste.

## MORE...

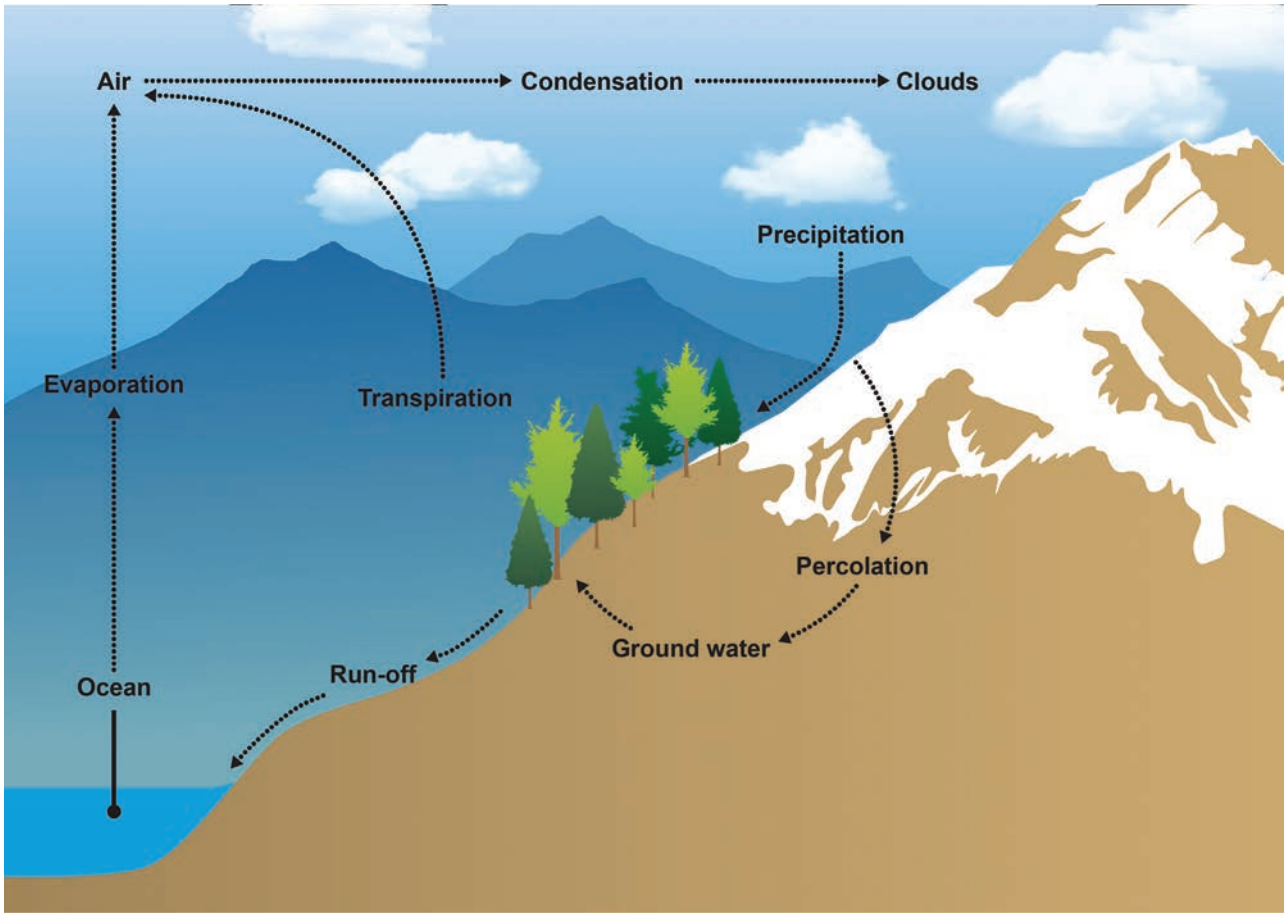
The WHO *Guidelines for Drinking-water Quality* define a framework for drinking water safety including limits for potential pollutants:

www.who.int/water_sanitation_health/dwq/guidelines/en

The United Nations Environment Programme (UNEP) publication *Clearing the Waters: A focus on water quality solutions* provides an overview of water contaminates, the impacts of poor water quality, solutions to deal with water quality problems and how they can be achieved:

www.unep.org/PDF/Clearing_the_Waters.pdf

## THE WATER CYCLE




The water cycle

The water cycle (see diagram) is unique in that water is present throughout only as the molecule $H_2O$, albeit existing in three physical states - vapour, liquid and ice. It is not chemically transformed.

Liquid water **takes in latent heat energy** to become water vapour; and water vapour condenses to liquid water, **releasing latent heat energy**. The amounts of energy involved are very large and the dynamics of weather are in great measure driven by them.

Although there appears to be a vast abundance of water available on the planet, most of this is seawater. Only a small fraction of it is freshwater that is readily available to us for drinking, industry, agriculture, etc.

Distribution of Water Across the Planet

| Location | % of Total |
|---|---|
| Oceans | 97.24 |
| Glaciers and icecaps | 2.14 |
| Groundwater aquifers | 0.61 |
| Lakes (freshwater) | 0.009 |
| Inland seas | 0.008 |
| Moisture held in soil | 0.005 |
| Atmospheric moisture | 0.001 |
| Rivers | 0.001 |
| **Total** | 100% |

Drinking water typically sourced from:

- Rivers and lakes, known collectively as 'surface waters'.
- Groundwater, e.g. via springs, wells and boreholes.
- Artificial reservoirs, e.g. created by building dams across river valleys.

Drinking water may also be obtained from the desalination of seawater, but this is highly energy intensive and expensive.

**GLOSSARY**

**POTABLE**

Suitable for drinking.

Being such a valuable and essential resource, water is:

- Continuously re-used and recycled and great attention is paid to protecting rivers and groundwater.
- Often vigorously protected by criminal law, with significant penalties available to the courts for anyone who pollutes a source of drinking water.

Water sources are often controlled by stringent legislation around the world. In many countries, it can be an offence to discharge into the following types of watercourse without a permit or other legal authorisation:

- Relevant territorial waters.
- Coastal waters.
- Inland freshwaters.
- Groundwater.

Permits are required under the UK **Environmental Permitting (England and Wales) Regulations 2010** where anyone wishes to discharge into the above waters.

## WATER FOR AGRICULTURE AND INDUSTRY

Agriculture (70%) and industry (22%) account for the greatest proportion of all of the freshwater abstracted from surface and groundwaters worldwide. The proportion of water used by households for drinking and washing is comparatively small (8%).

Large quantities of water are used for irrigating crops – although the actual amount varies considerably between different regions and climates. A large quantity of water is also used for farm animals (both directly for drinking. and also indirectly through the food they eat). For example, about 15m$^3$ of water is typically required to produce one kilo of beef.

Certain industries also consume significant amounts of water. Water may be incorporated directly into food and drink products, and also some chemical products (e.g. water-based paints). Water may also be used in manufacturing as process water, especially for cooling (e.g. power stations, steel production) and for cleaning.

## IMPACT OF WATER POLLUTION ON WILDLIFE

There is a number of critical ways in which pollutants can have an adverse impact on aquatic wildlife.

### Physical Impacts

Plants and animals that live on the bottom of rivers and lakes may become physically smothered by effluents that contain a high concentration of solids. Untreated sewage, run-off from mining, quarrying and construction activities may all contain high levels of suspended solids, such as silt, sand and organic particles.

High levels of suspended solids are also likely to make the water very turbid, reducing the light available for aquatic plants to grow. This will have a knock-on effect on animals that feed on the plants.

### Oxygen Stress

Plants and animals that live in aquatic environments depend on an adequate supply of oxygen for respiration – just like plants and animals on land. But land plants and animals get their oxygen direct from the atmosphere, whereas aquatic plants and animals must use oxygen that is dissolved in the water in which they live. Although oxygen makes up around 21% of the atmosphere (by volume) it is much less available in water. The amount of oxygen that water can hold in solution depends on a number of factors, especially temperature, but typically a litre of water will only contain 5-6 milligrams of dissolved oxygen – this is around 20 times less than a litre of air. Aquatic plants and animals are therefore extremely sensitive to any pollutant that reduces the oxygen content of the water.

Creating an oxygen stress is one of the most important mechanisms by which polluting effluents can affect aquatic wildlife. Effluents that contain high levels of organic material – for example, human sewage – strip oxygen from receiving waters. This is because the micro-organisms that feed on the organic material and break it down consume oxygen from the water column as they grow and multiply.

**Eutrophication** is a related process that also results in oxygen stress in aquatic environments. This is caused by excessive nutrients (for example, run-off of fertilisers from agricultural land) greatly enhancing the growth of aquatic plants, especially microalgae that live suspended in the water column. As the plants grow and multiply, they also consume the oxygen in the water, greatly reducing the oxygen that is available for animals such as fish.

The 'blooms' of microalgae created by eutrophication may also reduce the light available for plants that live on the bottom of the lake or river, restricting their growth.

## Toxics

A wide range of contaminants that may be present in effluents are potentially poisonous to aquatic wildlife. These include toxic metals such as copper, mercury and lead, spills of fuel and oil, and chemicals, such as solvents. Biologically-active materials, such as insecticides and herbicides, pose a particular threat if they contaminate aquatic habitats.

## Over-Abstraction

Excess demand for water, leading to over-abstraction from water sources, can also have detrimental impacts on aquatic wildlife. Water removed from ground and surface waters rarely returns to the source from which it has been taken. Around 80% of water applied to crops evaporates, for example. This can lead to many rivers flowing at low levels during times of peak demand or, in the worst case, they can dry up completely. Impacts of over-abstraction on rivers and aquifers include:

- Reductions in river-water flow reducing the size of the populations of aquatic species that the river can support.
- Wetland habitats that are supported by river flows drying up and disappearing.
- Aquifers drying up, removing important sources of water for human consumption and agriculture.

In coastal areas, removing water from aquifers at an excessive rate can lead to saltwater intrusion, making the water unfit for use.

## Water Conservation

With less than 1% of the water on the planet actually available for use, water should be treated as a valuable resource. Even in countries where it is comparatively readily available, we should make an effort to conserve water where possible. This conservation also has a direct and positive effect on energy savings, as energy is used throughout the process that brings water to our taps.

Some of the ways to conserve water include:

- Toilets – if installing a new toilet, ensure it has a dual flush system which allows less water to be used if a full flush is not required. Indeed, consider not always flushing the toilet; even a short flush system uses several litres of clean water and may not always be necessary. If you have the older, single-flush system, then consider a water-saving device, such as a "Hippo" – a plastic container open at the top that retains a portion of the water that would have been used in the flush.
- Fit a water meter – knowing you are being charged for what you use is a great incentive to reduce water consumption. It can also save you money on both your water bill and sewerage bill as this is calculated from the amount of water you use.
- Stop dripping taps – according to Waterwise (a not-for-profit water organisation funded by the water industry), a dripping tap wastes at least 5,500 litres of water a year.
- Water garden plants in the evening – this ensures that more of the water remains available to the plants and so in the long run less has to be used.
- Fit diffusers on taps – they won't make much difference when filling a bowl or basin, but if you wash anything under a running tap they will reduce the amount of water needed.
- Grey water recycling – using bath and washing water to flush the toilet can save large quantities of fresh, clean, drinking water from simply being flushed away.
- Fit low flow showerheads and take more showers than baths.

## THE POTENTIAL EFFECTS OF POLLUTION ON WATER QUALITY

Drinking contaminated water may affect human health in a variety of ways, depending on the concentration and nature of the contaminant.

Environmental enforcement bodies often assess and classify the quality of rivers and other water bodies. The assessment method can look at both the ecological (considering fish and invertebrate species present) and the chemical status (e.g. concentrations of pollutants such as heavy metals, pesticides and nutrients) of the water. The classification system identifies where the water quality is good or where it needs to be improved.

One common ecological method of classifying river quality uses invertebrate species as a basis for measurement. Known as the Biological Monitoring Working Party (BMWP) score, it attaches a score between 1 and 10 to species of aquatic invertebrates depending on their tolerance to pollution (the less tolerant a species is, the higher the score). Sensitive species, such as stonefly nymphs, attract a score of 10, while more tolerant species, such as worms, have a much lower score. By using a simple hand net, a sample can be obtained and examined and scores given for the number of species found in the sample. (Note that scores are for number of species, not number of individuals found, so five stonefly nymphs still attract a score of 10, as would one stonefly nymph.)

### GLOSSARY

**AQUATIC INVERTEBRATES**

Animals without a backbone living in a water environment.

As we saw in Element 1, excessive levels of nitrates and phosphates in relatively still waters, such as lakes, can lead to a process of nutrient enrichment known as **eutrophication**.

### MORE...

The UN *Water Quality Policy Brief* provides information on the challenges, trend drivers and impacts related to water quality. You can find it at:

www.unwater.org/downloads/waterquality_policybrief.pdf

### REVISION QUESTION

1. Virtually all water bodies, such as rivers, lakes and groundwater, are protected by criminal law. Explain why it is important that **all** types of water body are protected.

(Suggested Answer is at the end.)

# Main Sources of Water Pollution

## KEY INFORMATION

- Water pollution can be caused by 'point sources' or 'diffuse sources'.
- Many sources of water pollution need to be controlled. These are: domestic waste waters (sewage), surface-water drainage, industrial discharges, process and cooling water, mining and quarrying, litter, agriculture, contamination from natural materials and unplanned discharges.

We have highlighted the need to conserve our precious water resources by using water wisely and not polluting the water that is available to us.

The main sources of water pollution that we need to control are discussed below.

## Domestic Waste Waters – Sewage

In the 1800s, populations began to rapidly increase - particularly within major cities. Untreated human waste was discharged into local rivers, resulting in an awful smell. This was a common issue across the world.

Although the network of underground sewers in most cities has dramatically improved the situation, domestic waste is still the greatest potential source of water pollution around the globe. This waste is often referred to as **sewage**.

Sewage comes from many sources:

- Domestic premises - toilets, sinks, baths and showers, dishwashers, washing machines, etc.
- Commercial premises, e.g. offices, industry, hotels and restaurants - all of the above.
- Rainwater - which runs from roads, pavements, roofs, etc. into drains which may also link to the sewers.

In the UK, we dispose of 11 billion litres of sewage every day. Historically, a very small proportion of this sewage would have been treated (if any). However, there are now international standards in place which control how sewage should be treated before being discharged into rivers or oceans.

It is still the case, however, that domestic waste water from many cities around the world – especially in developing countries – is still discharged untreated. This is a major source of water pollution.

The main pollutants in sewage are:

| Pollutant | Potential Impacts |
|---|---|
| Solid debris:<br>• Plastic waste<br>• Wood<br>• Textiles | • Litter on the surface of water and around river banks and shorelines. |
| Organic material:<br>• Human waste<br>• Food residues | • Using up oxygen as it decays - this is known as Biochemical Oxygen Demand (BOD). Can strip enough oxygen from the receiving water so that fish and other wildlife are unable to survive. |
| Suspended solids – silt, sand and organic particles suspended in the water | • Smothering plants and animals that live on the bottom of the receiving water.<br>• Clouding the water, reducing the light available for plants to grow.<br>• Toxic contaminants, disease-causing viruses and bacteria may adhere to these particles, which may in turn be eaten by aquatic animals. |
| Nutrients – nitrogen and phosphorus compounds | • Promoting excessive growth of microscopic plants, which strip oxygen from the water. |
| Toxics - metals (such as copper, nickel and lead) and oil | • Poisoning of wildlife and humans (if quantities are high enough). |

## Surface-Water Drainage

As we have seen, rainwater that runs off surfaces such as pavements and roads may drain into the sewer system and be treated with domestic sewage. However, many sources of surface drainage, for example from industrial installations, construction sites, quarrying and mining activities, may bypass the sewer network. This is a very important potential source of pollution of both surface and groundwaters.

Grit and silt from construction activities can run off into rivers and lakes

Rainwater that falls on surfaces will collect any contaminants that may be present. The range of contaminants will depend on the activities being undertaken on the site, but is likely to include dirt and other solids and residues of oil, raw materials and process chemicals that may be handled and spilt on site. There may therefore be a wide range of potentially hazardous materials entering surface water drains. These drains may discharge directly into surface waters, e.g. the local river (with or without treatment), or drain into a soakaway buried in the ground where contaminants may come into contact with groundwater.

On many industrial sites, especially older sites, the surface drainage system may be poorly understood and the final points of discharge may not be fully identified. This makes pollution incidents more likely; for example, in the event of a spill entering the surface water drainage system.

## Industrial Discharges

Liquid effluents are by-products of many industrial processes and industries. Many companies discharge their liquid waste into the existing sewage system; where it will be processed through a sewage treatment works before being discharged. However, some larger companies operate their own sewage treatment works and discharge directly into local waters in accordance with relevant legal standards. Unfortunately, in some parts of the world, the treatment stage is not required, or not enforced.

The operating processes of the following industries can produce huge volumes of liquid effluent:

| Industry | Water-Pollution Issues |
|---|---|
| Textiles | Washing, dyeing and rinsing fibres generates large volumes of wastewater. This wastewater is often contaminated with a range of chemicals, including traces of pesticides used on raw materials. |
| Pulp and paper manufacture | Pulping timber to make paper requires large quantities of water and results in an effluent with high levels of BOD and suspended solids.<br>Highly-toxic residues of chlorine from paper bleaching may also be present. |
| Manufacture and bottling of soft drinks and alcoholic beverages | Cleaning equipment and bottles and disposing of waste product generates large volumes of waste water with a high BOD. |
| Milk and associated dairy processing | Cleaning equipment and bottles and disposing of waste product generates large volumes of waste water with a high BOD. |
| PVC production (chloralkali processes) | Traditional chloralkali processes use mercury electrodes, meaning effluents may contain highly-toxic mercury compounds. |
| Titanium-dioxide production | This white pigment is extracted from natural minerals in a process that creates large quantities of acidic liquid sludge. |

## Process and Cooling Water

In some industries, water is used for cooling plant and equipment. Although coolant water is usually largely free from contaminants, it will have become hot. Discharging coolant water before it's cooled can cause the temperature of a river to rise by more than 10°C. Warmer water is able to hold less oxygen, meaning local wildlife can suffer as a result. Permits are often required to ensure the discharge of coolant water is properly managed and controlled.

Sectors which require a lot of water for cooling include: electricity generation; oil refining; steel-making; cement manufacture and paper manufacture.

## Mining and Quarrying

Mining, quarrying and associated ore-processing activities have the potential to create serious water pollution. Run-off is a particularly important source of contamination that may wash into nearby water courses, or seep into groundwater.

Run-off from mining and quarrying is likely to contain high levels of solids. As we have seen, discharges that contain excessive solids may smother aquatic life and reduce levels of light available for photosynthesis in the receiving water. Run-off may contain solids from:

- Extractive operations that use water, e.g. hydraulic processes to extract china clay.
- Mineral washing and processing activities.
- Water drained from excavations to allow work to continue ('dewatering').
- Spoil heaps and stock piles.
- Washing vehicles, work areas and equipment.

Oil and fuel spills are also an important source of contaminants in run-off from mining and quarrying sites.

Certain types of mineral extraction, e.g. the excavation of coal and metal ores, may expose rocks that contain sulphur. If water from the workings comes into contact with this sulphur, it can result in the formation of sulphuric acid. The resulting effluent is known as Acid Mine Drainage (AMD).

In addition to its acidic nature, AMD may contain potentially toxic metals in solution, such as lead, zinc, iron, mercury and cadmium. AMD is often a particular concern when mine workings are closed down, because disused working will tend to flood when active dewatering (i.e. pumping out) of the workings ceases, allowing exposed sulphur to mix with water.

An acidic run-off may also arise from spoil heaps and stockpiles of crushed and waste rock, known as Acid Rock Drainage (ARD), which can cause similar problems to AMD.

### MORE...

The Scottish Environment Protection Agency has produced a useful publication that contains further information on controlling pollution from mining and quarrying activities. It is available at:

www.sepa.org.uk/customer_information/mining_and_quarrying.aspx

## Litter (Plastics, Wood, Textiles, Etc.)

Significant amounts of litter, especially plastics such as old bottles and wrapping, end up in our rivers, lakes and on beaches. As well as being unsightly, old containers may contain residues of oil, fuel and other potentially hazardous materials.

Surface drainage systems can be an important route by which litter reaches the environment. Construction sites may also generate significant amounts of litter, and other solids, such as grit and cement dust, may be exported in run-off.

## Agriculture

Agricultural operations are often associated with potential water pollution:

- Hazardous liquids, such as fuel and pesticides, are often stored on-site.
- Animal waste may be stored in slurry pits.
- Large volumes of milk may be stored and uploaded.
- Silage and other effluent from feed stores.

Generally, agricultural pollution results from an unplanned release whereby these contaminants make their way into rivers - often through spillage or problems with storage.

The run-off of fertilisers and pesticides from fields is the most significant cause of water pollution associated with agriculture. Fertilisers are generally rich in nitrates and phosphates and, if used in inappropriate quantities, locations or times of year, these fertilisers can make their way into drainage systems and rivers. Because this type of pollution does not reach the river through a distinct source, it's known as **diffuse source**.

Raising the levels of nitrate in water can result in the excessive growth microscopic plants which remove oxygen from the water - meaning other wildlife are endangered. It was also be dangerous where the river water is used for drinking supplies because soluble nitrates are not always removed by water purification processes.

However, milk also presents a serious threat to the environment; if it enters a river it's high BOD can also be devastating.

## Contamination from Natural Minerals

Not all pollution comes from man-made sources; naturally-occurring minerals may also result in significant impacts. Two examples of natural pollutants are highlighted in the following cases:

- In Bangladesh, the main source of drinking water is groundwater. Arsenic has been identified in groundwater in many locations in the country and has caused widespread concern. Arsenic is a metal that is known to be a carcinogen (as well as having other health effects) and is soluble in water. Arsenic is present because it occurs naturally in the rocks through which groundwater flows.

  It is estimated that between 25 and 36 million people are exposed to arsenic levels that exceed the Bangladesh standard of 50 ppb (parts per billion). Tens of thousands of people have been identified as suffering from skin discoloration and other more serious complications of arsenic toxicity.

- Radon is a colourless, odourless, tasteless, naturally-occurring radioactive gas that is associated with igneous rocks, such as granite, that contain uranium. Radon gas may migrate to the ground surface and then penetrate and accumulate in buildings. Exposure to high levels of radon gas in the atmosphere increases the long-term risk of lung cancer.

  Large parts of Cornwall (a county in the south-west of the UK) are classed as radon-affected areas because 1% of domestic properties have a radon level above the safe limit of 200 becquerels of radioactivity per cubic metre of air ($Bq/m^3$).

  The most important route for radon to contaminate the atmosphere inside homes is through the direct migration of the gas from the underlying ground. However, in radon-affected areas, drinking water that is obtained from groundwater sources may also contain very small amounts of dissolved radon gas. This dissolved gas may be released from the water supply through activities such as showering, increasing levels of the gas in the indoor atmosphere.

## Unplanned Discharges

Many of the sources of water pollution that we have discussed so far result from planned activities, such as point-source discharges from industrial processes. Discharges from planned activities such as these are usually carefully controlled to comply with legal requirements, especially the conditions of any discharge permit.

But water pollution from unplanned activities can also be very significant. Accidental spills and leaks of fuel and liquid chemicals are the most common cause of unplanned discharges that can cause water pollution. Spills often happen when tanks are being re-filled or decanted. Old or disused tanks may also leak if they become damaged or corroded. Contaminating materials that occur on unmade ground (i.e. bare or unprotected ground) may be particularly difficult to control, because contaminants can migrate considerable distances through porous ground, such as sands and gravels, and eventually pollute groundwater a long way from the point of the spill.

While many spills are minor, some unplanned incidents can have massive environmental and economic repercussions. The Deepwater Horizon oil spill that took place in 2010 in the waters of the Gulf of Mexico was caused by an explosion on an oil-exploration rig. In all, 780,000$m^3$ of crude oil were discharged into the ocean, affecting marine and coastal ecosystems for hundreds of miles and resulting in more than US$50 billion costs for BP, the operator of the project.

Unplanned discharges may often result in diffuse pollution. For example, river pollution from the run-off of fertilisers and pesticides from agricultural activities (see above) is an important example of an unplanned discharge.

### REVISION QUESTIONS

2. State the two main categories of water pollution sources.
3. List any three of the main sources of water pollution.

(Suggested Answers are at the end.)

# Main Control Measures Available to Reduce Contamination of Water Sources

## KEY INFORMATION

- Contamination of water can be reduced by considering the control hierarchy.
- Permits to discharge, groundwater pollution and the framework for managing water are covered by various EU Directives.
- Reactive and active (proactive) methods can be used to monitor contamination of water sources.
- Physical measures to prevent or reduce pollution to water include:
  - Bunding of stores.
  - Use of oil interceptors.
  - Spill response procedures.
  - Coagulation to remove solids.
  - Correction of pH and temperature.
  - Screening, sedimentation, filtration and centrifugal separation to remove solids.

## CONTROL HIERARCHY

Many environmental enforcement bodies around the globe have responsibilities for the:

- Protection of water resources.
- Control of abstraction from and discharge to water resources.

You should be aware of the hierarchical duty to "eliminate, minimise and render harmless" emissions to the environment, which we covered earlier.

## TOPIC FOCUS

**Control Hierarchy for Water Pollution**

- **Eliminate:**
  - Replace chemicals that are harmful to the aquatic environment with non-hazardous alternatives.
  - Change of process to produce a solid rather than a liquid waste.
- **Minimise:**
  - Reduce the amount of water used in a process or activity.
  - Store smaller quantities of hazardous substances at any one time.
  - Reduce the amount of fertilisers used on agricultural land.
- **Render harmless:**
  - The techniques described in the subsection on Control Methods in this element either minimise pollutants or render them harmless before they are discharged to water.

## CONTROL METHODS

We will now look at some of the legal and physical controls available to reduce pollution of water resources.

### Permits to Discharge

Discharges of wastewaters to sewers, rivers, lakes and other watercourses must be within limits set by an enforcement body. Often, a permit to discharge is used as the key legal control in many jurisdictions. Parameters that are set in permits can vary but may include:

- Maximum permitted flow rate (daily and hourly).
- Temperature.
- Maximum Chemical Oxygen Demand (COD) or maximum Biological Oxygen Demand (BOD). These and related terms are described in more detail below.
- pH range (typically 5-9).
- Maximum concentration of suspended solids.
- Limits of amounts of dissolved oil, metals (e.g. copper, zinc), organic chemicals (e.g. phenols).
- Limits on pesticides and heavy metals (e.g. cadmium, mercury and lead).

You should also be aware that in the EU, limits for discharges to water can be set under an integrated permit as required by the **Industrial Emissions Directive (2010/75/EU)**.

## Groundwater Protection

Groundwater is an important source of drinking water and water for rivers and other watercourses. As groundwater is hidden away, the effects of pollution cannot be immediately seen. Because groundwater is vulnerable to pollution and can be easily damaged, there are specific policies and laws in place to protect it.

Groundwater pollution usually occurs gradually. The sources of groundwater pollution often include leaks from underground storage tanks and wash-off of contaminated rainwater. It can also be difficult to detect as it may move very slowly through porous rocks but in fissured aquifers it can move much faster.

As a result of its importance, groundwater is often protected by law. In the EU, for example, **Directive 2006/118/EC** (the **Groundwater Directive**) provides control on hazardous substances and non-hazardous pollutants that could contaminate groundwater.

*Table identifying examples of groundwater pollutants (the substances shown are those identified in the **UK Environmental Permitting (England and Wales) Regulations 2010**)*

| Groundwater Hazardous Substances | Groundwater Non-Hazardous Pollutants |
|---|---|
| • Heavy metals<br>• Pesticides<br>• Radioactive substances<br>• Hydrocarbons<br>• Discharges from septic tanks | • Ammonia<br>• Metals<br>• Biocides |

### MORE...

For further information on groundwater, consult the Environment Agency publication *Groundwater Protection: Principles and Practice (GP3)*, available at:

www.gov.uk/government/publications/groundwater-protection-principles-and-practice-gp3

## Framework for Managing Water

**Directive 2000/60/EC** (known as the **Water Framework Directive**) embodies the concept of integrated river basin management and sets objectives for water status, including:

- Ecological and chemical parameters.
- Common monitoring and assessment strategies.
- River basin administration and planning.
- Measures to meet the objectives.

One of the key aims of the **Water Framework Directive** is that all water bodies (and marine water 1km from the coast) will achieve a 'good' quality status both ecologically and chemically by 2015.

It takes an inclusive approach to water management, encompassing water flow through catchments from lakes, rivers and groundwater to estuaries and to the sea. It is being implemented in phases, with full compliance required by 2015.

## Monitoring Water Quality

Permit conditions may include specific monitoring (for water quality) and maintenance requirements. Monitoring should include a mixture of active (proactive) and reactive measures.

### TOPIC FOCUS

**Active and Reactive Monitoring**

**Active monitoring** is undertaken before there has been a failure. Examples would include:

- Sampling the quality, flow rate, pH and other parameters of the water discharge.
- Mass balance calculations for underground storage tanks.
- Site inspections to identify potential risks.
- Calibration of monitoring equipment to ensure accurate results.

**Reactive monitoring** is undertaken following a failure. Examples would include:

- Collecting data on near misses.
- Monitoring of complaints from neighbours or workers.
- Information on enforcement action.
- Records of past incidents or spillages.

(**Note**: similar active and reactive monitoring is appropriate for emissions to air.)

# Main Control Measures Available to Reduce Contamination of Water Sources

Active monitoring may be undertaken of both the quality of a process effluent stream prior to discharge into a receiving water, and the quality of the receiving water itself. In either case, the variables that are likely to be monitored are those that are typically included in permits to discharge:

- Flow rate.
- Temperature.
- pH.
- Concentration of suspended solids.
- Chemical Oxygen Demand (COD)/Biochemical Oxygen Demand (BOD)/Total Oxygen Demand (TOD).
- Concentration of dissolved oil.
- Concentration of dissolved metals.

Other tests for specific contaminants (such as a specific pesticide) may be undertaken if these are expected to be present or are of particular interest.

COD, BOD and TOD are methods of measuring the potential oxygen depletion that can be caused following discharge of pollutants into water. This occurs from the breakdown of organic materials by micro-organisms which subsequently take oxygen out of the water as part of the process of decomposition. Such oxygen depletion can severely affect aquatic life, killing fish for example (fish do not have enough oxygen to breathe). Substances that cause such pollution include milk, beer, sewage, blood, etc. As such, all have to be discharged within consent conditions (obviously, this may also be a legal requirement) and protected from spilling into surface waters and sewers.

## TOPIC FOCUS

**COD, BOD and TOD**

- **Chemical Oxygen Demand (COD)**
  - The COD test measures materials in a water sample that can be chemically oxidised.
  - The test is performed in a laboratory by reacting the water sample with a strong chemical oxidising agent, such as potassium dichromate, for a specified time (usually one or two hours) at a defined temperature.
  - In essence, a COD test determines the amount of organic matter by measuring the amount of oxygen the sample will react with.
  - COD is expressed in milligrams of oxygen per litre (mg/l).
  - The COD test is relatively simple and can be performed within about two hours.

(Continued)

## TOPIC FOCUS

- **Biological Oxygen Demand (BOD)**
  - Also known as Biochemical Oxygen Demand.
  - The BOD test measures all the materials in a water sample that can be broken down by the action of microbes.
  - The test is performed in a laboratory by incubating the water sample with a culture of micro-organisms for a specified time (usually 5 days) under defined conditions and then comparing the level of dissolved oxygen in the sample at the beginning and end of the test.
  - BOD is expressed in milligrams of oxygen per litre (mg/l).
  - The BOD test is more complex and time-consuming than the COD test.
- **Total Oxygen Demand (TOD)**
  - Measures all of the organic and inorganic compounds present in a sample of water that can be oxidised.
  - TOD is expressed in milligrams of oxygen per litre (mg/l).
  - May be undertaken by online equipment that only needs a few minutes to measure a sample.

**Note:** Although COD, BOD and TOD all provide measures of the potential oxygen depletion that can be caused by a polluting effluent, they do not give exactly comparable results. For example, the COD test does not measure the oxygen-consuming potential of certain organic compounds such as acetate, whereas acetate can be metabolised by micro-organisms and would therefore be detected by the BOD test. On the other hand, the oxygen-consuming potential of cellulose would not be picked up by a standard BOD test but would be detected by a COD test. It is important therefore that the most appropriate test is used in each situation.

## GLOSSARY

### MICRO-ORGANISM

An organism that is microscopic, including bacteria, fungi, microscopic plants and animals such as plankton.

## CONTROLS FOR STORAGE AND SPILLAGE

### Preventing Spillages

Since spillages of noxious chemicals are a ready source of pollution, the most effective strategy is to prevent spills in the first place:

- Sloppy chemical transfer practices create an unnecessary risk of spillage, whereas more careful operating procedures prevent or minimise such losses.
- Maintenance and inspection will identify potential or actual spills and leaks early on, preventing them from either developing or getting worse. For example, corrosion, if allowed to develop unchecked, will ultimately cause the container/pipe to fail.
- Proper storage of materials will also help prevent spillage, e.g. siting dangerous chemicals away from internal traffic routes or with barriers to protect from collision.

Corrosion of containers will ultimately cause them to fail

### Wastewater Treatment Lagoons

Lagoons can be used as a wastewater treatment technique. They can be of the following types:

- Wastewater treatment, storage and evaporation lagoons, e.g. for sewage treatment, food manufacturing and agricultural processing.
- Sedimentation basins and leachate collection ponds for landfill.
- Irrigation dams used for holding and treating wastewaters.
- Ponds used for collecting potentially contaminated stormwater run-off from sites.
- Processing and wastewater lagoons used in mining, wastewater treatment and manufacturing.

If lagoons are not controlled appropriately they can present a significant risk to the environment. They can lead to:

- Surface water pollution (e.g. through breach of lagoon walls).
- Groundwater pollution (e.g. through the use of an inappropriate liner).
- Odour and health impacts.

**MORE...**

For further information on spillage control management, see the publication PPG22 Dealing with Spills, available at:

www.sepa.org.uk/about_us/publications/guidance/ppgs.aspx

### Keeping Systems Separate

#### Appropriate Storage of Incompatible Materials

When incompatible materials come into contact with each other, e.g. during an accidental spill, the substances may react together to cause a fire or explosion or to form a toxic substance. Careful consideration of storage requirements given in material safety data sheets will assist in determining the appropriate storage arrangements. Consider the following:

- Are materials likely to result in a violent chemical reaction if they come into contact with one another?
- Should a fire occur involving one material, would fire suppression substances, such as water, cause a problem with other materials?
- Are flammable goods stored away from oxidising agents?
- Would a spillage of one material damage or disintegrate the packaging and containers of other stored materials?

## Bunding of Chemical and Oil Stores

### GLOSSARY

**BUND**

A secondary, impermeable container in which the primary container sits. Commonly used for larger storage vessels, bunds typically consist of a wall surrounding the primary container, the inside surfaces (and floor) all being rendered impermeable. The bund is sized to 110% of the volume of the primary container.

While specific legislation in a country or region should be consulted on the storage of chemicals and oils, one key requirement is to use a suitably designed and constructed bund.

Storage of hazardous liquid materials in drums and Intermediate Bulk Containers (IBCs) also needs secondary containment. The recommended size of the secondary containment volume for oil storage in England and Wales is identified in the table below; it also provides a good guide to the secondary containment volumes required for other liquid substances:

| Container Type | Minimum Secondary Containment Volume |
|---|---|
| Single drum | Secondary containment for drum storage can be provided by a drip tray with at least 25% of the volume of the drum. |
| Multiple drum | Secondary containment for drum storage can be provided by a drip tray with at least 25% of the total drum storage. |
| Single IBC | You can't use a drip tray with only 25% storage capacity if you're storing oils in an IBC.<br>Secondary containment with at least 110% of the container volume. |
| Multiple IBCs | Secondary containment with a minimum of either 25% of the total volume of the containers or 110% of the largest container, whichever is the greater volume. |

Based on: PPG26 Drums and intermediate bulk containers, Environment Agency, SEPA and NIEA, 2011 (www.gov.uk/government/publications/storing-and-handling-drums-and-intermediate-bulk-containers-ppg26)

### GLOSSARY

**DRIP TRAY**

A simple tray placed under storage containers to collect minor leaks and spills.

**INTERMEDIATE BULK CONTAINER (IBC)**

A container used for the storage and transport of liquids and other bulk materials. They are cubic in shape and usually constructed of plastic surrounded by a metal cage. They often have pallet bases so they can be moved by a forklift truck.

## Spillage Control Management

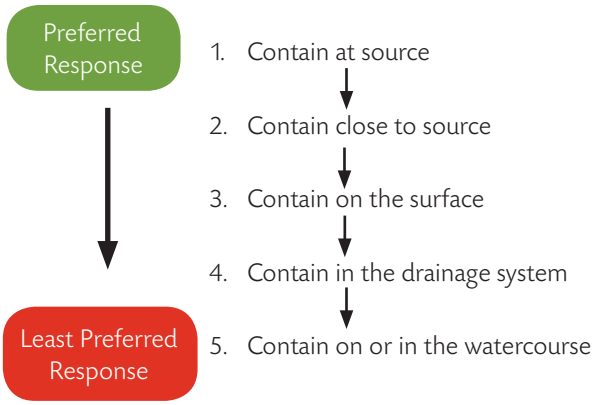
When a pollution incident occurs, the spillage can escape from a site via different routes, including:

- Through surface water drainage system.
- Directly into a watercourse.
- Through soil, soakaways, damaged drains and surfaces to groundwater.
- To the foul sewer.

The methodology for spillage control management is:

- **Pollution Risk Assessment**
  A risk assessment should take into account all the above routes in addition to issues such as:
  - The properties (physical, chemical and biological) of the pollutants spilt.
  - Impacts of accidents.
  - Vandalism.
  - Containment failure.
  - Flood risk.
- **Pollution Incident Control Plan**
  Following determination of the risk of pollution, a pollution incident control plan can be developed to ensure that an effective response is in place should an incident occur.
  Training of staff is important to ensure that the plan is effectively implemented. For example, staff should:
  - Know what they should and should not do following a spill.
  - Be aware of where pollution control equipment and PPE are located and the location of the pollution incident control plan.

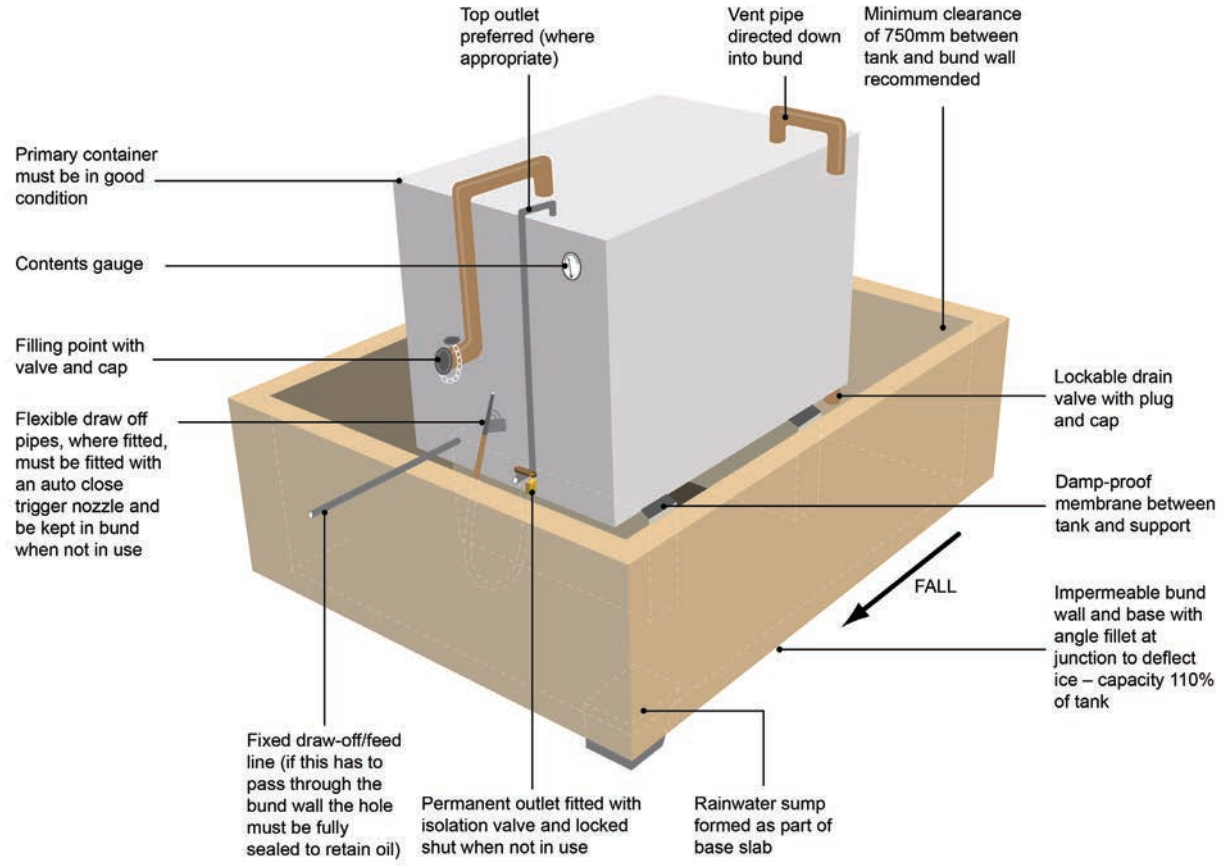
When planning a spill response, the following hierarchy should be considered:



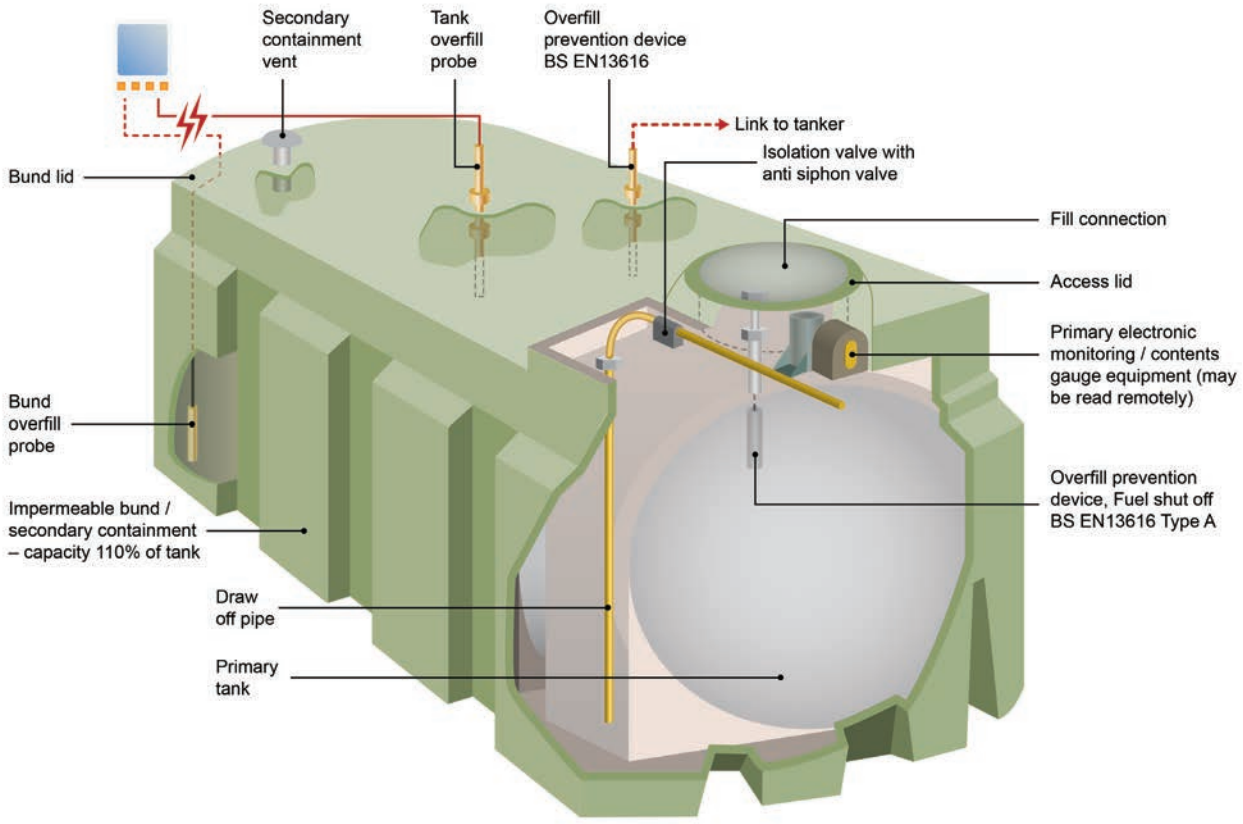

The pollution control hierarchy

- **Contain at source**: the most effective measures are to stop a spill at the source where the primary or secondary containers have been breached, such as sealing the damaged container/pipework with proprietary sealant or turning the container so the damaged area is at the top.
- **Contain close to source**: this includes moving the leaking material to an undamaged container, using sorbent product to soak up the spill or using a small container to capture the spill.
- **Contain on the surface**: the next option is to prevent the material from entering the drainage system or unsurfaced ground. Methods to achieve this include booms and drain mats.
- **Contain in the drainage system**: if a spill has entered the drainage system then it should be retained there and prevented from entering the environment. This can be achieved by shutting valves, blocking drains or closing oil separators.
- **Contain on or in the watercourse**: environmental damage can be reduced by containment on the watercourse prior to the spill spreading. This can be achieved by deploying a boom or damming a watercourse.

- **Site-Specific Pollution Control Options**
  The pollution risk assessment may identify that site-specific pollution control will be needed, such as on-site structures that can be used to divert or pump a spill to provide pollution containment. Examples include containment lagoons and ponds, tanks, sacrificial areas and pits and trenches.
- **Spill Clean-Up**
  Any spillage needs to be cleaned up and disposed of in line with legal requirements for waste. A review should also be completed of how the incident occurred and the effectiveness of the response plan.




Single-skinned oil tank within an open bund (after Pollution Prevention Guidelines PPG2)



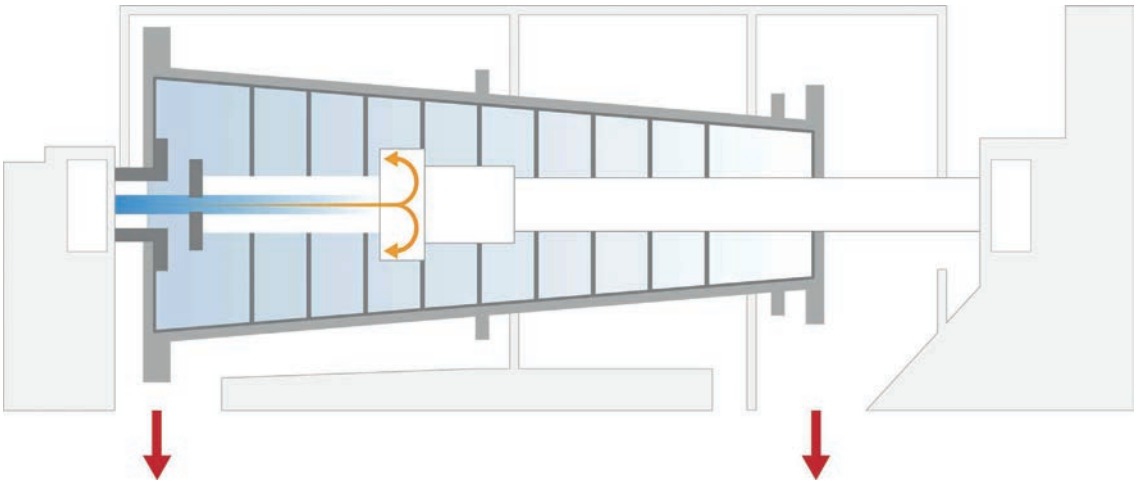

Integrally bunded tank (after Pollution Prevention Guidelines PPG2)

## Use of Oil Interceptors

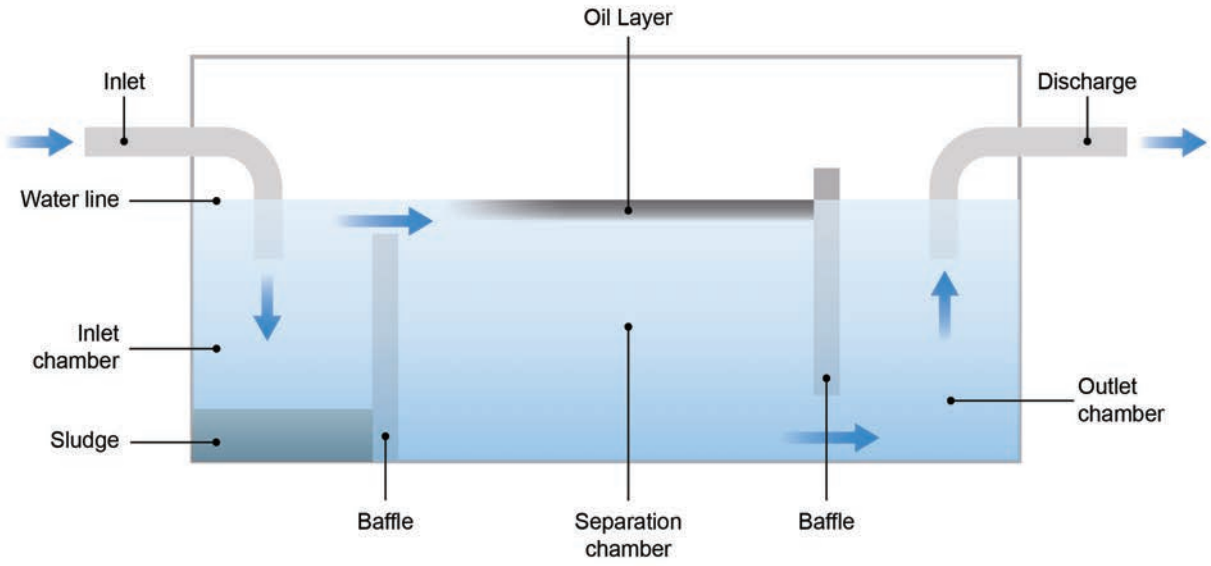
Oil interceptors use the fact that oil (including oil-based fuels) floats to prevent it being discharged. Regular inspection of interceptors is essential to ensure they are not blocked or overloaded with excess volumes of oil. Different types of oil interceptors are available for different uses. For example, oil interceptors are used in surface water drainage systems from hard standings such as car parks (where obviously oil leaks from car engines can build up).

## Decanter Centrifuge

A centrifuge operates to clarify an effluent around a centre line. The unit rotates at high speed around its centre line and, as it does so, the impact of gravity is replaced by that of centrifugal forces which can be around 4,000 times that of gravity. Such force can be used to cause effective separation of solids from liquids at a much faster rate than sedimentation.



Simple Decanter Centrifuge




Simple oil interceptor

# Main Control Measures Available to Reduce Contamination of Water Sources

## Separation and Marking of Drain Systems

Sewerage and surface water systems should not mix. Process water should also be kept separate, if possible, as this will enable any sources of pollution to be more easily identified. Drain covers should be marked with both the type of drain (surface, sewer, process, etc.) and the direction of flow. A clear colour-coding system should be used and the direction of flow should not be marked on the cover itself but on the surround. Usually, blue is used to denote surface water drainage (i.e. for uncontaminated rainwater) and red for foul water drainage (i.e. for sewage and/or trade effluent).

## Dealing with Spillages

Provision of spill kits suitable to deal with the type of pollution likely to occur and training in the proper use of the kits are an important control system. The kits must be maintained and available at the locations where spills are likely to occur, as quick action is required if pollutants are to be prevented from entering the water source.


## CONTROLS FOR WASTE WATER

## Screening

This is a simple process which uses a screen (e.g. stainless steel mesh) to filter out large solids and organic matter (such as sticks, weeds), commonly used in water treatment works.

## Solids Separation and Removal of Organic Load (Coagulation)

Fine particles such as clay, metal oxides and some organic substances are difficult to settle out of suspension under natural conditions. Coagulants are used to encourage these particles to come together in what are known as "flocs". Aluminium is a commonly used coagulant. Once the coagulants have been added, the water must be mixed at high speed to ensure effective mixing takes place. Once thoroughly mixed, the water is passed to another tank where it is stirred slowly, allowing even larger flocs to form. Eventually, the water moves to another tank where there is very little movement and the flocs sediment out to the bottom.

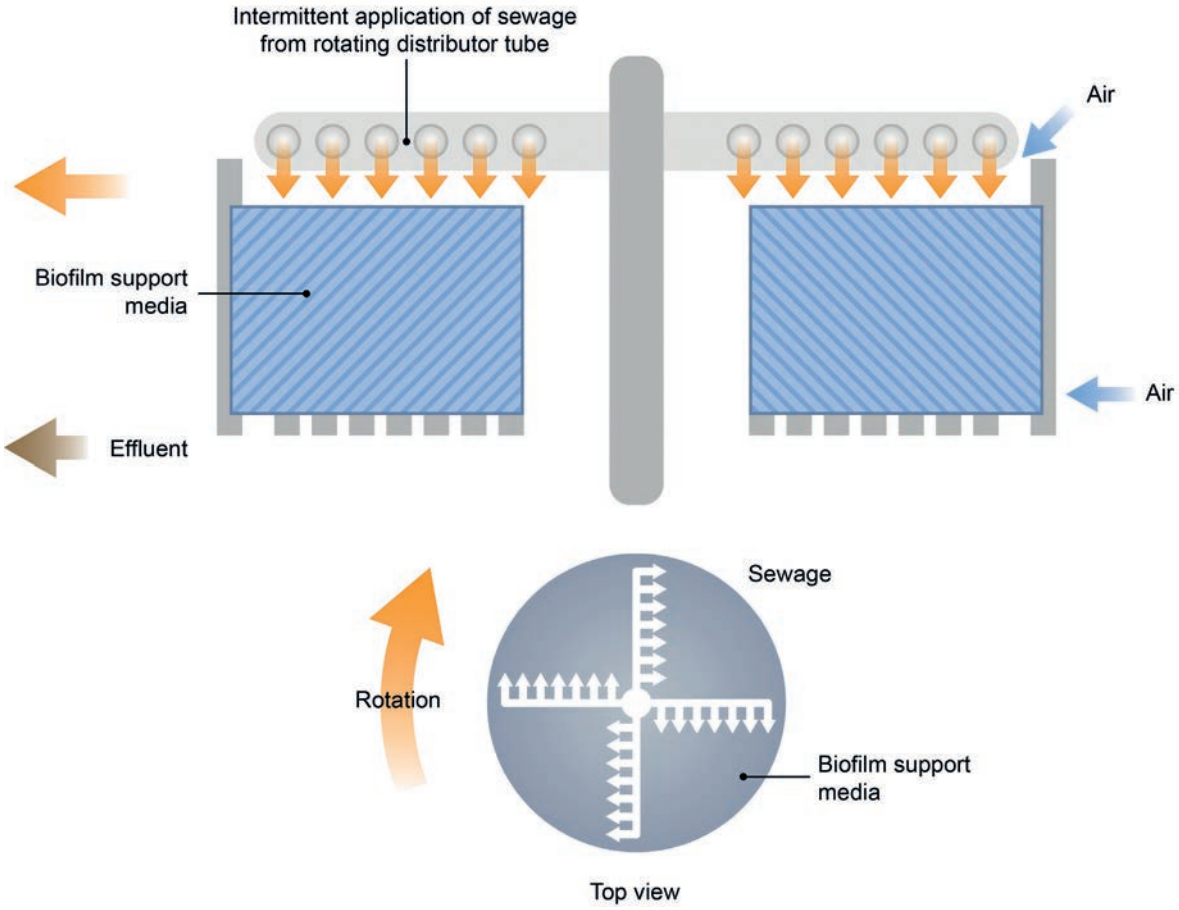
## Sedimentation/Flotation

Sedimentation is where the water is stored in a tank and any suspended solids are able to sink to the bottom under gravity. Alternatively flotation can be used, where air is blown into the water increasing the buoyancy of the particles as they absorb air. When they reach the surface they can be skimmed off using rotating blades.

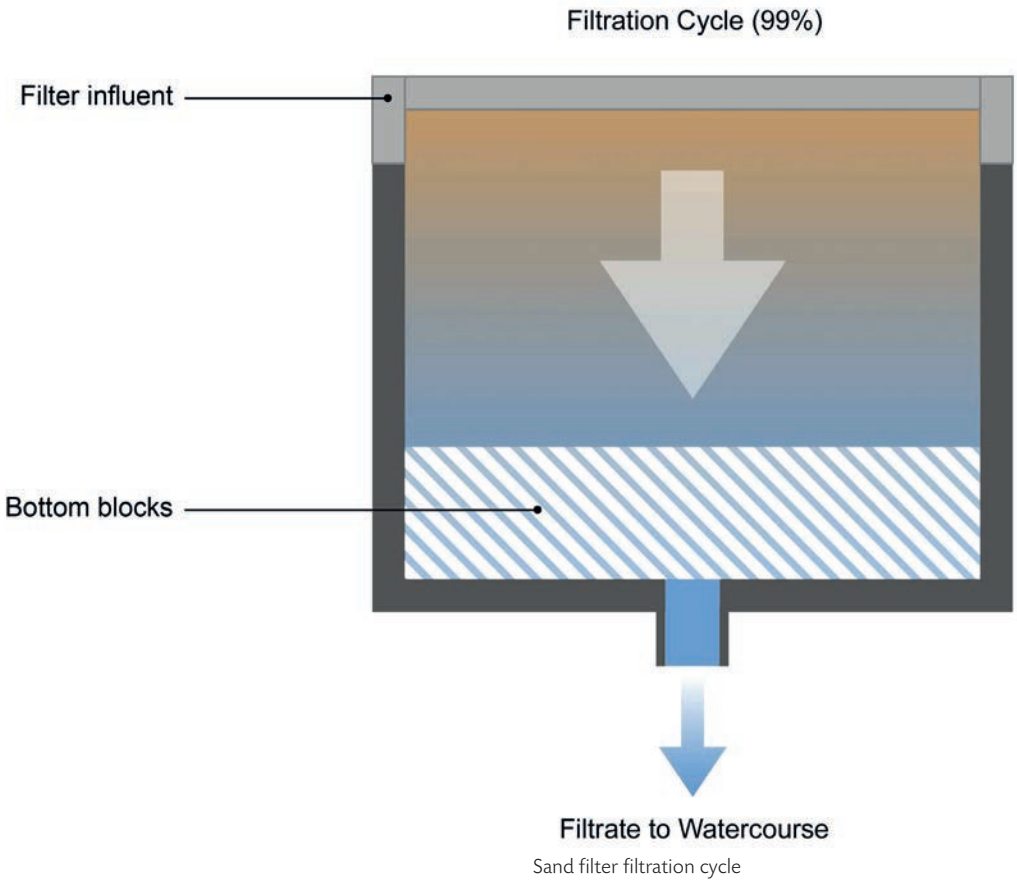
## Filtration

Filtration is a separation technique whereby solids are trapped in a filter medium and the liquid is allowed to pass through. Depending on the nature and extent of the solids loading, different media can be used. For example, tertiary treatment of water in a sewage works would typically involve the use of a sand filter (anthracite may also be used).

Primary treatment of sewage commonly uses **biological** or **trickling filters**. This is where primary settled sewage is intermittently spread by a rotating distributor tube over a bed of gravel. Liquor flows over the surface of the gravel, on which a biofilm of micro-organisms develops and grows by digesting the sewage. It seeps down and is collected at the bottom. It is important that the beds do not become waterlogged.




Trickling filter system - cross-section and top view




Sand filter filtration cycle

# Main Control Measures Available to Reduce Contamination of Water Sources

## Centrifugal Separation

Centrifugal separation is really a form of accelerated settling. Normal settling leads to relatively slow separation of solids from liquids, forming a sediment at the bottom under the influence of gravity. In centrifugal separation, the water is fed into a centrifuge that spins at high speed. The centrifugal forces act on the heavier particles in the water, forcing them to the outside where they are collected and fed away from the water. The clean water passes through the system. The technique is typically used to de-water sludge (from sewage treatment operations).

## Correction of pH

As mentioned earlier for discharge consents and permits, the pH has to be adjusted to within certain limits. If the waste water is too acidic, it can be adjusted with alkaline materials such as lime (calcium oxide/hydroxide) or sodium carbonate. If it is too alkaline, it can be adjusted with acids such as hydrochloric acid.

### REVISION QUESTION

4. List five methods used to reduce contamination of water resources.

(Suggested Answer is at the end.)

## UNIT EC2: ENVIRONMENTAL PRACTICAL APPLICATION

Now that you have studied approximately half of the course, you should be in a position to send your tutor a rough outline of your practical application.

You should have already decided on your chosen area and approached management to ensure that they are happy to co-operate in terms of providing information. You should also have discussed with them any confidentiality issues that may exist. Now you should send your tutor a brief outline of the area you intend to cover and the issues you expect to encounter there.

There are a couple of points to remember before you submit this:

- The area must be sufficiently simple and small to allow you to complete the practical application within three hours (even if this means selecting a small area within the site, such as a warehouse, maintenance depot or single production area, if your site is large).
- The NEBOSH proforma to be used for the practical application (explained in your guidance for Unit EC2):
  - Is designed to cover the principal topics contained in the syllabus.
  - Will help you to structure your practical application work.
  - Will help you in completing your outline for your tutor.

You can see from it the kind of issues that NEBOSH expect you to cover in your practical application, so don't forget to look at it. Some sections in the proforma may not be relevant to your particular site, but your chosen area does need to cover a sufficiently wide range of topics.

Submit your outline plan for your practical application to your tutor, by e-mail or by post (using the submission form you can obtain from NEBOSH).

If you have any queries on the proforma before you submit your outline, contact your tutor for help.

# Summary

## SUMMARY

This element has dealt with the control of contamination of water sources.

In particular, this element has:

- Explained that water supply companies have a legal duty to supply water that is fit to drink, sourced from groundwater, reservoirs and rivers. Varying levels of purification are required to produce water which is clear, palatable, safe and reasonably soft.
- Outlined the water cycle and sources of water.
- Emphasised that water should be treated as a valuable resource. Methods of water conservation include dual flush toilets, installation of a water meter and grey water recycling.
- Outlined the main sources of water pollution, including domestic waste waters, surface-water drainage, industrial discharges, process and cooling water, etc.
- Described the main sources of water pollution, including:
  - Drainage from mining.
  - Surface water drainage.
  - Contamination from spills and leaks, sewage, process and cooling water.
  - Solids, such as grit, plastics, etc.
- Outlined the main control measures available to reduce contamination of water sources, including:
  - Permits for discharge to surface, groundwater and public sewer systems.
  - Controls for storage and spillage: prevention of spillages in the first place with the use of appropriate procedures and techniques, appropriate storage, wastewater lagoons, separation and marking of drain systems, use of oil interceptors, bunding of chemical and oil stores and speedy clearing of spillages.
  - Controls for waste water: screening, solids separation and removal of organic load (use of "flocs"), centrifugal separation (accelerated settling), sedimentation/flotation, filtration (solids are trapped in a filter medium and the liquid passes through), and correction of pH.

## QUESTION 1

**Describe** the water cycle. (8)

## QUESTION 2

(a) **Outline** the following terms associated with water pollution:

(i) Chemical Oxygen Demand (COD). (2)

(ii) Biological Oxygen Demand (BOD). (2)

(b) **Outline TWO** contrasting examples of pollutant sources that may cause oxygen depletion. (4)

### APPROACHING QUESTION 1

As before, using good exam technique you must:

- Read the question.
- Consider the marks available. In this case, there are eight marks available so you should spend around nine minutes answering the question and provide eight pieces of significantly different information.
- Highlight the key words. In this case, they would include 'Describe', 'water cycle'.
- Read the question again.
- Jot down an outline plan. This might include:
  - Evaporation, transpiration, respiration, clouds, precipitation, ice/glaciers, groundwater, abstraction, recharge, purifying effect.

Note that this is a 'Describe' question so a fuller answer is required, which is represented by the full eight marks being available with no subdivision of the question.

### SUGGESTED ANSWER TO QUESTION 1

Now you have finished your answer, read the suggested answer below and compare it to your one.

The essential features of the water cycle include that water is evaporated by energy from the sun. Such water sources include lakes, rivers and the sea. Plants also emit water vapour to the air through the process of transpiration and animals through respiration. Water vapour forms clouds higher up in the atmosphere. Cooling leads to condensation (vapour to liquid) which forms rain, ice or snow, which will then fall back to the surface of the Earth. It may also fall onto glaciers or in cold regions of the world where it will form ice. The precipitation will also fall directly onto watercourses. The precipitation may also fall onto the ground where it may form groundwater. Humans may abstract water from the ground or from surface water. Groundwater often feeds into watercourses, thus completing the cycle. The water cycle plays an essential role in naturally purifying water of contaminants and pathogens.

Now have a go at the question yourself.

## APPROACHING QUESTION 2

- Read the question.
- Consider the marks and time available.
- Highlight the key words. In this case, they would include:

  (a) 'Outline', 'chemical oxygen demand', 'biological oxygen demand'.

  (b) 'Outline', 'TWO contrasting examples', 'pollutant sources', 'oxygen depletion'.
- Read the question again.
- Jot down an outline plan. This might include:

  (a) (i) Oxygen consumed, oxidising agent, heated, inorganic/organic matter.

  (ii) Micro-organisms, incubating, five days, organic.

  (b) Food production, sewage treatment, agriculture, brewing (two only).

Now have a go at the question yourself.

## SUGGESTED ANSWER TO QUESTION 2

Now you have finished your answer, read the suggested answer below and compare it to your answer.

(a) (i) COD is the amount of oxygen that is consumed from an oxidising agent (such as potassium/sodium dichromate) when an aqueous sample is heated (usually for four hours under acidic conditions). The oxygen may be consumed by organic and some inorganic matter.

(ii) BOD is determined by incubating an aqueous sample with oxygen and micro-organisms present for five days at a temperature of 20°C. The oxygen is mainly consumed by biodegradable organic matter.

(b) Two of the following:

Waste from food production could be an important source of pollutants with a high BOD. Ingredients such as milk could cause increased oxygen demand on water, should they be spilt or released.

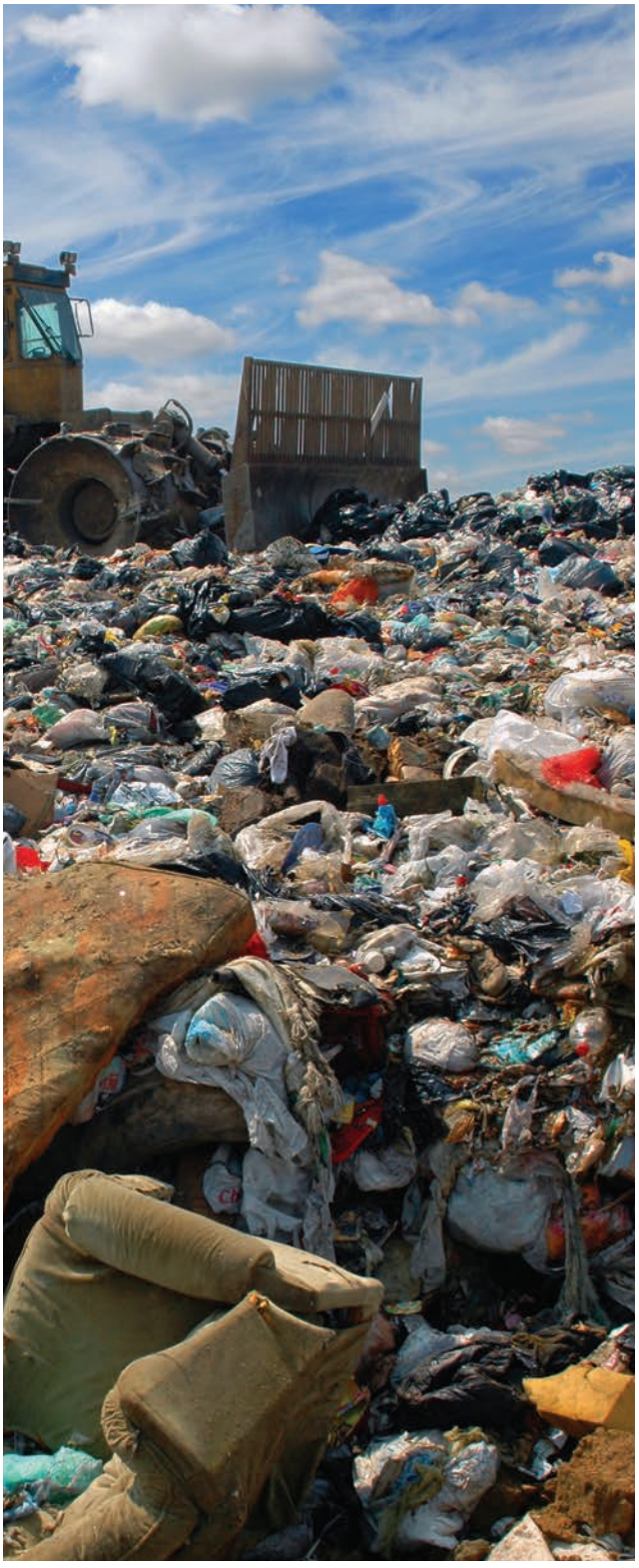
Sewage released from sewage treatment works due to breaches in containment or pipes may cause sewage to spill into a nearby watercourse, causing an increase in oxygen depletion.

Slurry and silage liquor from farms can also cause oxygen depletion. It may be released from a breach of containment or from spreading too much slurry onto the land (particularly when ground is frozen or saturated).

Brewing may also be a source of high BOD materials. A spillage of beer or aqueous by-products of the brewing process can have a high oxygen demand.

# CONTROL OF WASTE AND LAND USE

ELEMENT 6



## LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Outline the significance of different waste categories and the relationship between category and route of disposal.
2. Explain the importance of minimising waste.
3. Outline how to manage waste.
4. Describe outlets available for waste.
5. Outline the risks associated with contaminated land.

# Contents

## KEY INFORMATION

- Waste can be defined as "any substance or object which the holder discards or intends or is required to discard".
- Waste can be categorised in a number of ways. Common categories are: inert, hazardous, non-hazardous, clinical and radioactive.
- **EU Directive 94/62/EC on Packaging and Packaging Waste** commits member states to take measures to stop the production of packaging waste including programmes to encourage the re-use of packaging.
- Construction sites produce significant quantities of waste.

## THE WASTE FRAMEWORK DIRECTIVE

'Waste' is a term we all think we understand, but the legal issues surrounding the definition of waste are complex. There are many different types of waste that may be encountered in practice, and it is important to understand the various categories because of the differences in the way that they are regulated.

The **EU Waste Framework Directive**, first adopted in 1975, is the foundation of waste regulation and aims to ensure a uniform approach to waste management across the EU. Member states must:

- Adopt the waste hierarchy (i.e. give priority to waste prevention and encourage re-use and recycling).
- Ensure that waste is handled safely and without harming the environment.
- Ensure that waste management activities are authorised.
- Establish an adequate infrastructure of waste management installations.
- Prepare waste management plans.
- Ensure that waste producers bear the costs of disposal in line with the 'polluter pays' principle.

## DEFINITION OF WASTE

Article 3(1) of the current version of the Directive (**2008/98/EC**), retains the original 1975 general definition of waste as:

"...any substance or object which the holder discards or intends or is required to discard".

Anything discarded or dealt with as waste must be presumed to be waste unless proved otherwise. A 'Yes' answer to any of the following questions should clarify any doubts about the matter:

- Would it normally be described as waste?
- Is it a scrap material?
- Is it an effluent or other unwanted substance?
- Is it broken, worn out, contaminated or spoilt?
- Is it being discarded as if it were waste?

### MORE...

Further information can be found in Defra's: *Guidance on the legal definition of waste and its application (2012).*

www.gov.uk/government/uploads/system/uploads/attachment_data/file/69590/pb13813-waste-legal-def-guide.pdf

Waste materials can be categorised in a number of ways. The categories that are most typically recognised in legislation around the world are described below.

## INERT WASTE

Broadly speaking, this is waste which is stable, i.e. it does not degrade physically, chemically or biologically, nor does it dissolve, burn, chemically react or leach out to any degree that could be considered ecotoxic. Examples would include uncontaminated bricks, glass, concrete and tiles. If there is any suspicion of contamination, these items cannot be considered inert waste. The **Landfill Directive 99/31/EC** provides further criteria on what constitutes inert waste.

## GLOSSARY

### ECOTOXIC

Generally taken to mean 'damaging to the environment', although it is a general term and does not account for levels of toxicity, e.g. very toxic or toxic. Nor does it account for the sensitivity of specific species or ecosystems, e.g. an ecotoxic substance may be very toxic to one species but have little, if any, harmful effect on another.

## HAZARDOUS WASTE

Certain wastes pose a particular danger to human health or to the environment. The **Waste Framework Directive** (Annex III) identifies the properties of a waste material that render it hazardous. In summary, this covers substances that are:

- Explosive.
- Oxidising (substances which are highly reactive in contact with other substances).
- Highly flammable.
- Irritant (substances that can cause inflammation of the skin or mucous membranes).
- Harmful (substances which may involve limited health risks).
- Toxic (substances that may involve serious health risks).
- Carcinogenic (substances that may induce cancer).
- Corrosive (substances that may destroy living tissue on contact).
- Infectious (substances that contain disease-causing micro-organisms).
- Mutagenic (substances that may damage or change hereditary genetic material).
- Release toxic gases in contact with water, air or an acid.
- Sensitising (substances that can elicit an allergic reaction).
- Ecotoxic (substances that present a risk to the environment).
- Waste that may yield another substance after disposal that exhibits any of the above properties (e.g. waste in a landfill that generates a toxic leachate).

Examples of some commonly encountered wastes that meet one or more of these hazardous waste criteria are:

- Liquid fuels, such as petrol and diesel; solvents such as white spirit (explosive; highly flammable).
- Strong acids or alkalis, e.g. battery acid or bleach (oxidising; irritant; corrosive).
- Insecticides, wood preservatives or old medicines (harmful; toxic; ecotoxic; sensitising).
- Waste oil, batteries containing lead, cadmium or mercury, fluorescent lighting tubes containing mercury (toxic; ecotoxic; mutagenic).
- Contaminated textiles, such as used bandages or dressings, asbestos (infectious; carcinogenic).

Disposal of hazardous wastes is managed by specialist companies who operate dedicated chemical plants. Recovery of waste oils, solvents, etc. is usually followed by incineration of the residues, which must be carefully controlled to minimise production of substances such as dioxins and furans. This involves careful control of incinerator temperatures and cleaning of effluent gases.

(Note that in Scotland the term 'special waste' is equivalent to 'hazardous waste' in most other countries.)

## MORE...

The UK environmental regulators have produced a useful guide on how waste material should be assessed to determine whether it should be treated as legally hazardous:

*Waste Classification: Guidance on the classification and assessment of waste (WM3)* – available at:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/427077/LIT_10121.pdf

## NON-HAZARDOUS WASTE

Wastes which are controlled under legislation, but are neither inert, nor exhibit any of the properties of hazardous wastes, are classified as non-hazardous. This category actually accounts for a high proportion of the wastes that are generated on a day-to-day basis by households and businesses, including paper, card, plastic packaging, cans and food waste.

Despite the name, non-hazardous wastes have the potential to cause significant environmental impacts. Many of these wastes are biodegradable, or may be corroded by the action of weather. If these wastes are landfilled they may generate methane gas which is a potent greenhouse gas, and generate toxic leachate with the potential to contaminate surface and groundwaters.

## CLINICAL WASTE

Clinical waste is, effectively, a special category of hazardous waste, often treated separately in legislation because of the need for special methods of treatment and disposal. Clinical wastes are healthcare wastes which could harm people if they come into contact with them. The definition is wide-ranging, but includes:

- Soiled surgical swabs, dressings, etc.
- Excretions.
- Blood or body fluids.
- Human and animal tissues, carcasses, etc.
- Syringes, needles or other sharps.
- Drugs or other pharmaceuticals.


Clinical wastes and healthcare wastes

Clinical waste should be **segregated** from general waste; **separate bins, signage and training** should be provided to encourage this. There are various methods for achieving this, for example:

- Soiled surgical dressings should be put into heavy-duty yellow bags (2/3 full) and securely fastened.
- Sharps should go into properly designed sharps containers.
- Laboratory material, where risk of pathogens is high, should be autoclaved before being included with other clinical waste.

## GLOSSARY

### AUTOCLAVE

Equipment which uses high-pressure steam to sterilise material.

## RADIOACTIVE WASTE

Radioactive waste is also a special category of hazardous waste that is governed by specific legislation. The International Atomic Energy Agency (IAEA) defines radioactive wastes as being:

> *"waste that contains, or is contaminated with, radionuclides at concentrations or activities greater than clearance levels as established by the regulatory body".*

In practice, this definition covers:

- High volumes of waste from the nuclear power industry where the level of radioactivity may vary from low to very high.
- Low volumes of waste produced by other businesses that use small quantities of radioactive materials in laboratories and in sensing and monitoring equipment.

Radioactive warning sign

## CONTROLLED WASTE (UK)

In the UK, the term 'controlled waste' is often used. Controlled waste is any waste which is controlled by the relevant legislation (especially the **Environmental Protection Act 1990** and the **Control of Pollution Act 1974**).

Controlled waste effectively covers all of the waste that is likely to be encountered, including that from households, commerce (including construction and agriculture) and industry (including mining and quarrying).

## REVISION QUESTIONS

1. Define 'waste'.
2. Identify the criteria used to classify waste as hazardous.

(Suggested Answers are at the end.)

## KEY INFORMATION

- Minimising waste can help organisations make significant cost savings by following some practical steps, such as reviewing current practice, identifying opportunities for improvement, setting KPIs and targets, training and monitoring performance.
- The waste hierarchy defines the most desirable methods for waste management through to the least desirable.
- There are a number of benefits, limitations and barriers to waste minimisation, re-use and recycling.

The increasing volume of waste generated by the developed world is one of the biggest problems facing the planet today. In the developing world, it is also a major worry, with increased populations and higher standards of living, both contributing to significant increases in waste. Packaging is often highlighted as an area of significant waste and there are still major reductions that can be made in many areas of packaging. However, not all packaging is bad. Much of it protects goods from being damaged in transit and without some packing more damage, and therefore waste, would occur. As an example, a shrink-wrapped cucumber remains saleable for 14 days, whereas without wrapping it lasts just three days.

## TOPIC FOCUS

**Waste Minimisation in Practice**

Waste minimisation has clear benefits for society but can also result in significant cost savings for organisations. Some practical steps for achieving waste minimisation are outlined below:

- **Current Practice**

  The process should start by undertaking a review of current practice. Measurement is at the heart of this activity:

  – How much of exactly what type of waste is currently being created in particular areas of the organisation?
  – Waste arisings should be classified and quantified by type (e.g. paper, card, scrap metal, empty containers, chemicals, waste raw material, etc.) and by category (i.e. inert, hazardous, non-hazardous).
  – What disposal routes are currently being used for each type of waste? Which disposal contractors are being used?
  – How much did it cost in the last year to dispose of each waste stream?

  Note that much of the information and data required can be obtained by reviewing statutory documentation, such as waste transfer notes and hazardous waste consignment notes.

- **Identify Opportunities**

  Having established what is happening at the moment, identify potential improvements:

  – Is the organisation ordering surplus goods that it does not need?
  – Are manufacturing processes using raw materials efficiently?
  – Are there opportunities for investing in more resource-efficient equipment or processes?
  – Can any materials that are currently going to waste be re-used elsewhere in the organisation?
  – Is it possible to switch to more efficient waste contractors?

(Continued)

## TOPIC FOCUS

- **Set KPIs and Targets**

  It should now be clear what the current unit costs for waste disposal are and what improvements can reasonably be achieved. This information can be used to:

  – Set KPIs (e.g. waste produced per unit of production or output; wastes costs per unit of production).
  – Set improvement targets.
- **Responsibilities and Training**

  – Nothing will happen unless clear responsibilities are identified for waste management.
  – Everybody in the organisation needs to be trained so they can play their part, e.g. understanding how particular wastes should be dealt with on site.
- **Monitor Performance**

  – Performance against KPIs and targets needs to be assessed.
  – Cost savings achieved need to be calculated.
  – Improvements need to be communicated widely within the organisation. Cost savings are powerful incentives for supporting waste minimisation programmes.

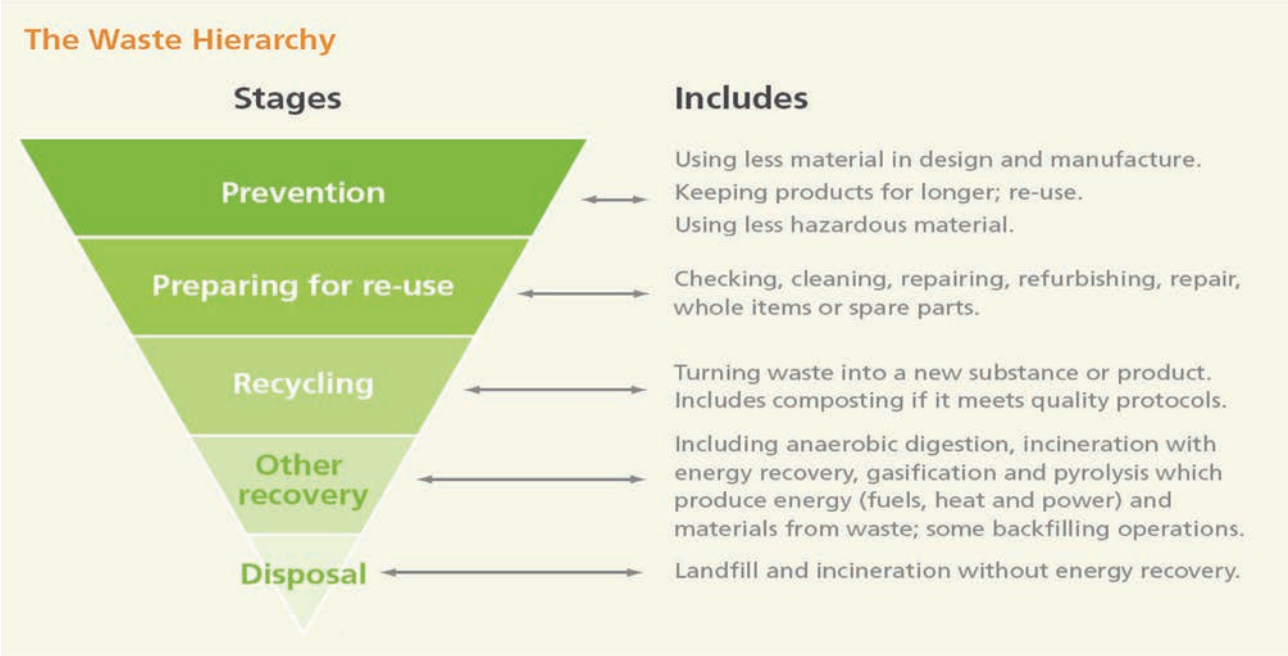
## MORE...

WRAP was established to facilitate improvements in resource efficiency in the UK, and has produced a number of useful publications to help organisations minimise waste. These are available from:

www.wrap.org.uk/category/subject/waste-reduction

## THE WASTE HIERARCHY

The waste hierarchy defined in the **Waste Framework Directive** is a system of applying best practice to the management of waste. The current waste hierarchy is:




Source: Government review of waste policy in england 2011, DEFRA, 2011 (www.defra.gov.uk/publications/files/pb13540-waste-policy-review110614.pdf)

## TOPIC FOCUS

**The Waste Hierarchy**

- **Waste Prevention and Reduction**
  Clearly, the best option is not to produce the waste at all. If this cannot be achieved then producing less waste is desirable. Techniques include designing products so that they produce no or less waste in manufacture or use, or considering the repair, re-use and ability to be recycled of the full product or component part. Examples of this are soft drinks bottles that contain approximately 25% less plastic than when plastic bottles first started to be used.
- **Preparing for Re-use**
  This includes activities such as repairing, cleaning and inspection so that products or components of products may be re-used without any type of pre-processing. Examples include inspecting and fixing (if required) pallets, and washing and re-using bottles for the same purpose.
- **Recycling**
  The range of products that are now recyclable is increasing every day. However, a product is not fully recycled until it goes back into the market and is purchased as a new product. Glass, metal and paper are all frequently recycled. In recent years, plastics have become more acceptable to recycling as new products have been developed.
  Composting involves the breakdown of organic materials, such as food and garden wastes by bacteria, fungi and insects into fertiliser. There are many local authority collection and composting schemes or it can be done locally at your organisation or home.
- **Other Recovery**
  Energy can be recovered from waste, e.g. by:
  - Recovering the heat generated when burning waste such as at waste-to-energy incinerators.
  - Burning methane generated on a landfill site to provide heat and energy.
- **Disposal**
  Responsible disposal should only be considered if none of the above options are appropriate.
  The two main methods for final disposal are landfill and incineration without energy recovery, which we will look at in more detail later.

## BENEFITS, LIMITATIONS AND BARRIERS TO RE-USE AND RECYCLING

### Benefits

To ensure that recycling is undertaken, the benefits of recycling should be communicated to key stakeholders. Such benefits include:

- **Raw material reduction** – if more waste is recycled then fewer raw materials need to be extracted, with a subsequent reduction in environmental impacts.
- **Corporate image** – communicating recycling schemes in corporate reports and by other means is good for an organisation's image and will help improve the reputation of the organisation, both internally and externally.
- **Pollution minimisation** – recycling results in less pollution, as extra raw materials do not have to be extracted and processed and the product is not disposed of to landfill.
- **Morale** – recycling schemes require the participation of the workforce, which should provide them with a sense of pride that the organisation is improving its environmental performance.
- **Energy reduction** – recycling saves energy and associated economic and environmental costs. Many metals require much less energy to recycle in comparison to being produced from ore. Reductions in energy will also result in minimisation of air pollutants from energy generation.
- **Cost** – recycling is generally a more cost-effective way of dealing with waste. Money can be gained for sending waste for recycling, in addition to not having to pay landfill tax.
- **Employment** – recycling creates jobs in collection and processing of wastes.

## Limitations and Barriers

The barriers to recycling are many and varied, depending on the point in the waste management chain that you examine.

- **Limitations on storage space** – many homes and organisations lack space in which to segregate and store different bins for different waste streams.
- **Perceptions and attitudes** – getting individuals both at home and at work to think about recycling and separation of waste as part of their normal routine. Education is the key to overcoming this barrier. Not being rewarded for recycling can also have a negative effect.
- **Consistency of service** – differences in how local authorities collect recyclables and what they will not collect lead to confusion as to what can be recycled and what cannot.
- **Markets for recyclables** – the markets for recyclables still need significant investment to develop new processes and new products that can use recycled materials, and prices need to be closer to the 'standard' products. Often, recycled products are seen as inferior in quality and more expensive. This situation does not encourage the market to develop.
- **Legislative restrictions** – waste legislation can make it difficult to take a material out of the waste stream once it is defined as waste.

### GLOSSARY

**CARRIER**

The person transporting the waste.

- **Inadequate encouragement for re-usable containers** – supermarkets do not encourage the use of re-usable containers and, as the majority of people do most of their shopping in supermarkets, this has a significantly adverse impact on the development of this market. There are a few small shops now opening that require customers to bring their own containers to refill them with everything from sweets to washing powder. Supermarkets are, however, moving towards 'bags for life' rather than plastic carriers.

There are many other barriers to re-use and recycling, but most of these are caused by systems designed for the convenience of business. Changing these processes, often going back to good practices undertaken in the past, could bring significant positive improvements.

Additionally, the following can help overcome some barriers:

- Improving collection of waste for recycling, with more regular doorstep collections.
- Improving communications on recycling and practical advice on how to recycle.
- Ensuring that people and organisations are aware of the benefits and success of taking part in a recycling scheme.

### REVISION QUESTION

3. List the five basic elements of the waste hierarchy.

(Suggested Answer is at the end.)

# Managing Waste

## KEY INFORMATION

- Responsible waste management requires consideration of:
  - Segregation, storage and labelling.
  - Transport methods and documentation required for transport.
- Differing requirements for waste management exist in different countries; managing waste in a particular country requires a good knowledge of that country's environmental legislation.
- Specific EU Directives exist which set out requirements relating to:
  - Packaging waste.
  - Electronic and electrical waste.
- In some countries, construction sites are required to develop and implement site waste management plans.

The waste chain is a series of steps that waste will go through, from producer to point of final disposal or recycling, when it becomes another product ready for use, rather like a chain of custody for evidence. As we shall see below, **Directive 2008/98/EC** on waste (referred to as the **Waste Framework Directive**), requires a producer to ensure that waste is handled correctly at each stage in the chain. Until the waste has reached a point of final disposal or been recycled, it remains the responsibility of the producer.

## RECOGNITION OF THE KEY STEPS

The key steps are:

- On-site separation.
- Storage.
- Transportation.
- Disposal.

We will look at these and other aspects in more detail later, but first we will consider the issue of responsible waste management.

## RESPONSIBLE WASTE MANAGEMENT

The principal legislative instrument covering waste management in the European Union is the **Waste Framework Directive (2008/98/EC)**. The Directive:

- Applies to all waste except radioactive wastes, waste from extraction and prospecting of mineral resources, non-dangerous agricultural wastes, waste waters, decommissioned explosives and unexcavated contaminated land.
- Encourages the implementation of the following hierarchy:
  - The prevention or reduction of waste production and its harmfulness.
  - The recovery of waste by means of recycling, re-use or reclamation or the use of waste as a source of energy.
- Ensures that waste is recovered or disposed of without endangering human health or the environment.
- Establishes an integrated and adequate network of disposal installations.
- Requires:
  - Member states to establish or designate the competent authority or authorities to be responsible for implementing the Directive; the competent authority is required to draw up a waste management plan.
  - Undertakings which carry out waste operations to obtain a permit from the competent authority.
  - Establishments or undertakings which collect or transport waste on a professional basis to be registered with competent authorities.
  - That in accordance with the 'polluter pays' principle, the cost of disposing of waste must be borne by the holder or producer.

- Sets new recycling targets to be achieved by EU member states by 2020, including recycling rates of 50% for household and similar wastes and 70% for construction and demolition waste.
- Strengthens provisions on waste prevention through an obligation for member states to develop national waste prevention programmes and a commitment from the EC to report on prevention and set waste prevention objectives.
- Sets a clear, five-step 'hierarchy' of waste management options (as covered earlier) according to which prevention is the preferred option, followed by re-use, recycling and other forms of recovery – with safe disposal as the last recourse.
- Clarifies a number of important definitions, such as recycling, recovery and waste itself. In particular, it draws a line between waste and by-products and defines when waste has been recovered enough – through recycling or other treatment – to cease being waste.
- Establishes that member states must implement legal arrangements to ensure that:
  - Holders of hazardous waste do not mix different categories.
  - Holders of waste keep records.
  - Movements of hazardous waste are accompanied with manifests.

## ON-SITE SEPARATION AND STORAGE INCLUDING SEGREGATION, IDENTIFICATION AND LABELLING

Good waste management starts at the very beginning of the process. Once different waste products are mixed it becomes increasingly difficult, and therefore expensive, to separate them later. Different wastes require different storage containers and it is important that the right container is used for the right waste. For example:

- Heavy cardboard can be stored in a container that is quite open, although it should be under cover to prevent the cardboard getting wet.
- Paper, especially shredded paper, requires a closed skip as it is easily blown away.

## TOPIC FOCUS

**On-Site Separation and Storage**

To ensure that waste is managed appropriately and does not escape from control, the following is required:

- Prevention of:
  - Corrosion or wear of containers.
  - Accidental spills or leakages.
  - Breach of containment by weather.
  - Blowing away or falling from vehicles or storage.
  - Scavenging by vandals, thieves, children, trespassers or animals.
- Protection of waste while it is held (cover skips, store liquids in bunded enclosures).
- Ensuring that waste reaches the next holder intact. (If the next stage is a waste transfer station, it will be sorted and mixed so that excessive packaging is not needed.)
- Segregating incompatible wastes (preventing cross-contamination of waste).
- Ensuring security (secure against waste attractive to scavengers, e.g. building materials). Waste left for collection should be adequately secured and left for a minimum of time.
- Labelling waste where appropriate and in accordance with the hazardous substance legislation.

## TRANSPORTATION INCLUDING TRANSFER TO AN AUTHORISED PERSON AND REQUIRED REGULATORY DOCUMENTATION

Transportation is also strictly controlled. In particular, it often requires documentation that follows the waste from the point of production to final disposal, recycling or re-use.

### TOPIC FOCUS

**Waste Transportation**

Waste holders should ensure that:

- Waste is transferred only to a waste carrier, who must be registered with a competent authority.
- Carriers are fit and suitable to handle and dispose of the waste. The holder/producer ultimately remains responsible for the fate of the waste so if, for example, it is taken by a carrier and fly-tipped, it will be the holder's/producer's task to persuade a court of law that he acted within the members state's law that implements the relevant parts of the **Waste Framework Directive**.

As we have stated previously, when transporting waste internationally, the requirements of the Basel Convention should be considered. In the EU, this is implemented through **Regulation (EC) 1013/2006**, the requirements of which include:

- Hazardous waste for recovery is not permitted to be exported to non-OECD countries.
- Non-hazardous waste for recovery can be freely traded between EU member states and OECD countries. It is subject to controls stated in the regulations.
- Hazardous waste shipped for recovery between emerging states and OECD countries must have prior written notification from the competent authority of despatch, destination and transit and their consent prior to shipment beginning.
- Possible controls for non-OECD countries include prohibition, prior written notification and consent (these are set out separately in **Regulation 1418/2007**).

## Regulatory Documentation

In the UK, regulatory waste documentation is required when waste is removed from a site (the systems used in other countries may be different, but share similar principles). For general waste, this takes the form of written information, which must describe the waste, the current holder and the person collecting the waste.

This must be retained for two years. In a similar manner, a consignment note is required for hazardous waste. This consignment note:

- Describes the:
  - Nature of the waste.
  - Process producing the waste.
- Includes the six-figure code from the EU List of Wastes.
- Remains with the waste until point of final disposal, being further completed by each waste carrier in the chain of custody.

Consignors and carriers of hazardous wastes must keep a register of the consignment note copies for three years; consignees of the waste must keep all such consignment note copies until they surrender the licence for the disposal site they manage.

### GLOSSARY

**CONSIGNOR**

The person producing the waste and causing it to be removed from the premises.

**CONSIGNEE**

The person receiving the waste for treatment or disposal.

### MORE...

For more information on hazardous waste, go to:

www.gov.uk/dispose-hazardous-waste

## DIFFERING REQUIREMENTS FOR WASTE

You should be aware the requirements for managing domestic, commercial and industrial waste can differ in many countries. Across the European Union, however, member states' arrangements will share some similarities, as they have been designed to comply with the **Waste Framework Directive**. A good knowledge of a country's environmental legislation is required in order to effectively manage waste in that country.

## DISPOSAL

Disposal must be to a permitted landfill site or other point of final disposal, such as an incinerator or treatment works. It is important that you understand where waste is being taken for disposal and ensure the carrier is registered with a competent authority (if required by law in the country of transfer) to take the waste you produce. Disposal options are explained later.

## PRODUCER RESPONSIBILITY

Producer responsibility is a policy tool that is an extension to the concept of 'polluter pays' that we considered earlier in the course. Its focus is to place responsibility for products when they get to the end of their life on the organisation that places the product on the market.

A former EU Environment Commissioner, Ritt Bjerregaard, described the aim of concept as follows:

> *"Many manufacturers have for too long considered the problems of waste management as if it was somebody else's problem. It is important to clearly underline that it is also their problem. We cannot come to terms with the ever-growing amounts of waste in a rational way, unless concerns for waste minimisation and recovery are built into the product from the start."*

## PACKAGING WASTE

**EU Directive 94/62/EC on Packaging and Packaging Waste** covers packaging that is placed on the market in the EU. Member states must take measures to stop the production of packaging waste, including programmes to encourage the re-use of packaging. Originally, the Directive set a target of between 50 to 65% of packaging to be recovered by 2001, and 25 to 45% to be recycled. It also sets out a number of essential requirements for packaging, such as requirements specific to the:

- Manufacturing and composition of packaging.
- Re-usable nature of packaging.
- Recoverable nature of packaging.

Packaging must also comply with a 100ppm limit by weight for cadmium, lead, hexavalent chromium and mercury.

## ELECTRICAL AND ELECTRONIC WASTE

### Waste Electrical and Electronic Equipment (WEEE)

The **Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE)** aims for the prevention of WEEE. If this cannot be achieved, re-use, recycling and other forms of recovery of such wastes should be undertaken so as to reduce the disposal of such waste (re-use of WEEE as whole appliances is favoured over treatment, recycling and recovery).

The Directive also seeks to improve the environmental performance of all operators involved in the life cycle of EEE. Ultimately, the aim is to minimise the quantity of such items ending up in landfill. The target is for member states to collect 20kg per person per year, on average.

Categories of WEEE defined in the Directive are:

1. Large household appliances.
2. Small household appliances.
3. IT and telecommunications equipment.
4. Consumer equipment.
5. Lighting equipment.
6. Electrical and electronic tools.
7. Toys, leisure and sports equipment.
8. Medical devices.
9. Monitoring and control equipment.
10. Automatic dispensers.

Key requirements of the Directive include the following:

- Member states developing and maintaining a register of EEE producers.
- Householders must be able to take WEEE to a collection facility at no cost.
- Developing targets for the WEEE collected separately from households.
- Distributors and retailers are responsible for making arrangements to take back WEEE for free, in a way that is convenient for the customer.
- Introduction of recovery and recycling targets for WEEE for various categories.
- Producers to mark EEE products with the 'crossed-out wheelie-bin' symbol.

## Restriction on the Use of Hazardous Substances

The objective of **Directive 2011/65/EU on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment** is to contribute to the protection of human health and the environmentally sound recovery and disposal of waste electrical and electronic equipment.

The Directive applies to equipment in the following categories:

- Large household appliances.
- Small household appliances.
- IT and telecommunications equipment.
- Consumer equipment.
- Lighting equipment.
- Electrical and electronic tools (except large-scale stationary industrial tools).
- Toys, leisure and sports equipment.
- Automatic dispensers.
- Electric light bulbs.
- Luminaires for use in households.
- Medical devices.
- Monitoring and control instruments, including industrial monitoring and control instruments.
- Other EEE not covered by the above.

New EEE put on the market must not contain more than the permissible maximum concentration values of hazardous substances. These are:

- 0.1% by weight in homogeneous materials for each of the following substances:
  - Lead.
  - Hexavalent chromium.
  - Mercury.
  - Polybrominated biphenyls.
  - Polybrominated diphenyl ethers.
- 0.01% by weight in homogeneous materials for cadmium.

## Waste Batteries

**Directive 2006/66/EC on Batteries and Accumulators and Waste Batteries and Accumulators** (accumulators are rechargeable batteries) has the following requirements:

- The use of cadmium and mercury is prohibited above certain limits in batteries (this varies for different battery types; some battery applications have exemptions).
- Specific labelling is required to facilitate recycling (the 'crossed-out wheelie bin' symbol; 'Pb', 'Cd', 'Hg' if it contains lead, cadmium or mercury, respectively).
- Appliances that use batteries are designed so that the batteries can easily be removed.
- Battery producers have to register with the regulator, join and finance a battery compliance scheme (which will carry out waste battery collection, treatment and recycling obligations).
- Portable battery sellers have to take back waste (i.e. spent) portable batteries free of charge but may pass these on to a battery compliance scheme.
- Waste industrial and automotive batteries must not be disposed of by landfill or incineration.

## WASTE FROM CONSTRUCTION PROJECTS

Waste from construction projects can cause numerous environmental impacts if it escapes. Examples include pollution to air, land or water, fire hazards, threat to human health (e.g. asbestos wastes) and the impacts of landfilling or other disposal or treatment techniques. In some countries, a site waste management plan is required for large construction projects, which identifies:

- Who is responsible for resource management.
- The types of waste that will be generated.
- How waste will be managed at each stage (with regard to the waste hierarchy).
- Which contractors will be used to ensure legal and responsible recycling and/or disposal.
- How the quantities of waste will be measured.

### REVISION QUESTION

4. Identify three ways in which waste could escape from control.

(Suggested Answer is at the end.)

## KEY INFORMATION

- Landfill sites and incinerators often require an environmental permit.
- Landfill sites can create a number of environmental impacts.
- Incineration can cause air pollution.
- In some countries, a tax is placed on all wastes going to landfill.

## LANDFILL AND INCINERATION AS ULTIMATE DISPOSAL ROUTES

(See also Element 7 on energy recovery.)

### Landfill

Landfill site management must adequately control and minimise any emissions, nuisances and litter, and this has implications during filling and afterwards. **Directive 1999/31/EC on the Landfill of Waste** (known as the **Landfill Directive**) requires that permitted landfill sites are:

- Geologically suitable.
- Impervious, e.g. clay or sandstone, but if not a membrane can be laid to make it so.

The design should:

- Minimise ingress of groundwater, which could arise due to changes in the local water table, flood conditions or the existence of springs or streams.
- Be finished with an impervious clay dome to shed rainwater.
- Allow for a system of porous pipes to be laid to collect and encourage drainage of landfill leachate.
- Allow any leachate which accumulates to be pumped to a foul sewer following analysis to determine its constituents. If 'Red List' contaminants, typically toxic metals, are present, pre-treatment will be required. Leachate management can be a problem with older sites which were not carefully designed; it may end up contaminating groundwater or invading local streams, especially in times of flood.

## GLOSSARY

### LANDFILL LEACHATE

Is liquid that drains or moves through a landfill. The liquid is either already in the waste or is caused by rainfall. It is often highly contaminated and can pollute nearby waterways and groundwater.

**Nuisances** must be adequately controlled, especially if the site is near a populated area:

- **Noise nuisance**: heavy vehicle movements, both site traffic bringing waste for disposal and site plant. Permit conditions may specify working hours.
- **Odours**: minimised by:
  - the cell method of filling;
  - ensuring the surface is covered with inert fill at the end of each working day; and
  - operating to minimise exposed areas.

  Chemical sprays to mask smells may be used in unusual wind conditions.
- **Dust and litter**: minimised by damping down and good site practice, e.g. cell filling by tipping down a gradual slope and using specially designed plant to bury litter and increase the fill density, maximising the site capacity and minimising later settlement. This also reduces the possibility of fire (producing smoke, smells and contaminated leachate) starting in the waste.
- **Vermin**: gulls, rats, mice and foxes. Good site practice is required, and possibly an eradication programme for rats.

Site security with a chain-link fence of suitable height will keep unauthorised persons out and help to catch wind-blown litter.

**Landfill Gas (LFG)** is a combustible mix of methane and carbon dioxide which can:

- Present explosion and toxic hazards to premises near the site by permeating through soil.
- Injure site-screening trees.

Municipal Solid Waste (MSW) contains sufficient putrescible material to give a good supply of landfill gas – production may continue for more than ten years. Such gas may be odourless and a detailed risk assessment should be undertaken, along with a programme of monitoring. Landfill gas is normally collected in pipes laid within the waste and is either flared off (burnt) or collected and used as fuel.

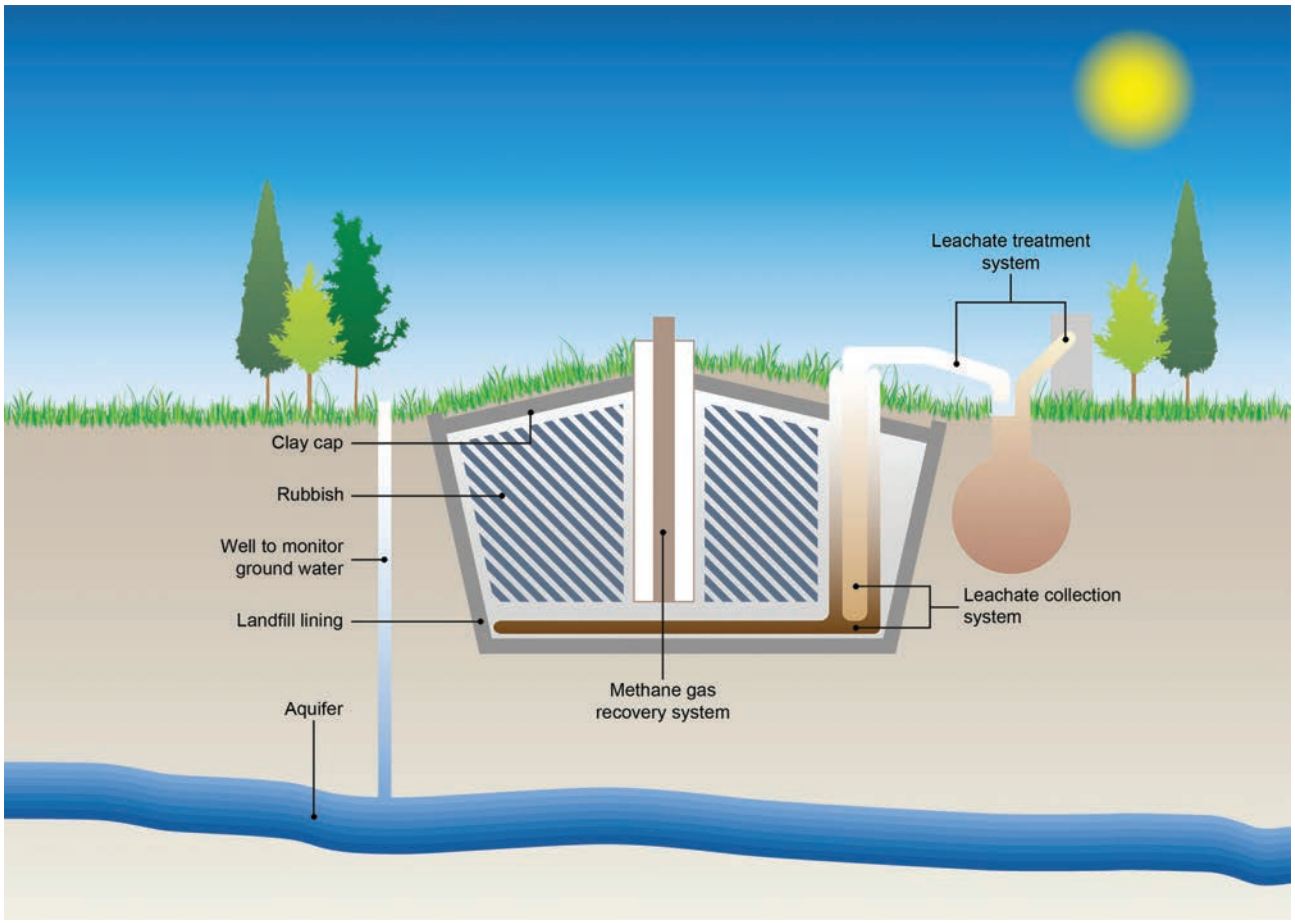
## GLOSSARY

**PUTRESCIBLE**

Capable of rotting/decomposing.

Landfill acceptance criteria require waste producers and treatment businesses to decide what level of treatment to pursue, according to the type of waste and the category of landfill it is to go to. Landfill sites are categorised according to the type of waste they are permitted to take, as follows:

- Inert waste sites.
- Non-hazardous landfills.
- Hazardous waste landfills.




Section through a typical landfill

## Incineration

Incineration with energy recovery requires:

- A capital-intensive plant.
- Detailed planning.
- An EIA.

MSW has about 40% of the calorific value of coal and is therefore a considerable source of energy. The BPEO (if you are not sure what this means look back at Element 1) for an incinerator project is usually **Combined Heat and Power (CHP)**. Waste reduction is 60-90% and results in clinker (usable for road-building), fly ash (landfilled) and metal (recycled).

In the UK, the Edmonton incinerator was designed to burn 400,000 tonnes per annum of MSW from five London boroughs. It takes 1,330 tonnes of refuse each day, produces superheated steam and drives four turbines supplying electricity to the National Grid, earning £4m per annum.

The temperature of combustion in the incinerator is controlled between 925 and 1,040°C; complete combustion is achieved by agitation of the burning waste turning and falling from roller to roller in the incinerator grate. From the final roller, burnt-out clinker and ash pass through a quench bath onto conveyors and are carried to the residuals handling area. Exhaust gas from the economiser passes through 50kV electrostatic precipitators before discharge to the atmosphere from the twin flues of the main chimney. The precipitators reduce the dust content of the gases to less than 60mgm$^{-3}$.

## TOPIC FOCUS

Advantages and Disadvantages of Landfill and Incineration

| | Advantages | Disadvantages |
|---|---|---|
| **Landfill** | • Comparatively cheap disposal.<br>• Can be used to restore areas used for quarries, etc. to local amenity use.<br>• Able to take large volumes of waste.<br>• Modern landfill is safe for humans and the environment.<br>• Can be used to generate electricity. | • Cheap, so does not encourage producers and consumers to migrate up the waste hierarchy.<br>• Waste does not break down quickly, so the problem of management remains for a considerable time after a site has closed.<br>• Poorly managed sites can lead to:<br>– Surface and groundwater pollution from leachate.<br>– Air pollution from unmanaged LFG or fires. |
| **Incineration** | • Reduction in volume.<br>• Allows heat to be recovered.<br>• An energy source. | • High initial cost.<br>• Volume of traffic.<br>• Monitoring of air pollution.<br>• Disincentive to recycling schemes (incinerators may need constant feeding). |

## OTHER TREATMENT OR DISPOSAL ROUTES

As well as landfill and incineration, there are other routes to disposal, including:

- **Domestic waste sites** – allow local residents to dispose of unwanted items that cannot be disposed of through the usual household collection system. Many now operate separate collections for many types of waste, such as used oil, cardboard, clothes, paper, metal, glass, etc. that feed into the local authority recycling process.
- **Waste transfer stations** – because many landfill sites and incinerators are long distances from where the waste is collected, most waste will pass through a waste transfer station. Local waste collection vehicles can carry about 10 tonnes of waste. This is 'bulked up' onto a larger vehicle with a payload of approximately 20 tonnes, before being transported to the point of final disposal, such as a landfill site. This reduces the volume of vehicles on the road and these larger vehicles are usually better adapted for driving on the landfill area. Many transfer stations are now operating as Material Recovery Facilities (MRFs) as well. This involves separating from the waste stream any materials that can be recycled and diverting them from landfill.
- **Waste treatment facilities involving recovery operations** – recovery operations may include:
  - Simple sorting of waste (as described above for MRFs) to divert recyclable and re-usable materials away from landfill/incineration.
  - Gas/heat recovery and electricity generation from landfill and incineration activities (as discussed earlier).

## WASTE DISPOSAL IN DEVELOPING COUNTRIES

Waste disposal in developing countries can sometimes be poor, presenting a major risk to people's health and the environment. Increasing amounts of waste and a change in composition are a key challenge to local governments. Often, the cost of disposal is beyond their financial means; there is also often a lack of capacity and political will to tackle the issue. Currently, the main way of dealing with waste is uncontrolled dumping. With the growth of industry and trade, the amount of hazardous industrial waste will rise, posing an even greater risk.

## COSTS AND THE IMPACT OF LANDFILL AND AGGREGATE TAXES

Taxes can be applied to waste, with the aim of reducing the volume of waste going to landfill and making alternative disposal options more financially viable.

The details of such taxes will vary between countries; as an example, specific taxes applicable in the UK are outlined below.

### Landfill Tax

In the UK, the **Finance Act 1996** introduced the Landfill Tax (LFT) with the aim of reducing the volume of waste going to landfill and making alternative options of waste disposal more financially viable. The **Landfill Tax Regulations 1996** actually regulate the Landfill Tax and HM Revenue and Customs (HMRC) collect it on behalf of the Government.

There are two rates of LFT:

- One for **inert wastes**, such as:
  - Naturally occurring rocks and soils, e.g. clay, sand and gravel.
  - Ceramic or cemented materials, such as glass, ceramics, bricks, pottery and china.
  - Ash from wood or coal combustion.
  - Gypsum and calcium-sulphate-based plaster, providing it is disposed of in a separate containment cell or in an inert landfill site.
  - Furnace slags.
- One for **active wastes**, such as:
  - Food and kitchen wastes.
  - Garden waste.
  - Packaging waste.
  - Agricultural waste.

Some wastes are usually exempt from LFT, for example:

- Naturally occurring minerals from mining and quarrying.
- Burial of domestic pets at pet cemeteries.
- Materials used in the engineering of the landfill site, such as:
  - Clay.
  - High Density Polyethylene (HDPE) used to line the base of the landfill.
  - Tyres used to create a drainage layer at the bottom of the cell.

The current rates for LFT are £2.60 per tonne for inert wastes and £82.60 per tonne for active waste.

The Landfill Communities Fund (formerly the Landfill Tax Credit Scheme) is a scheme whereby landfill operators are able to claim back a credit against their landfill tax liability. This credit (currently 5.1% of the tax liability) must then be used to help fund partnership projects that create significant environmental benefits, jobs and which improve the lives of communities living near landfill sites. The tax credit makes up 90% of the landfill operator's contribution to the partnership project scheme. The operator can then either make up the remaining 10% of the project cost themselves, or ask an independent third-party to contribute the difference.

The Landfill Communities Fund is administered by ENTRUST, which is a private company overseen by Her Majesty's Revenue and Customs.

### Aggregates Levy

Also in the UK, the **Finance Act 2001** enabled the Aggregates Levy to be introduced, which came into effect on 1 April 2002. The purpose of the tax is to:

- Address, by taxation, the environmental costs associated with quarrying operations (noise, dust, visual intrusion, loss of amenity and damage to biodiversity).
- Reduce demand for aggregates and encourage the use of alternative materials where possible.

The tax was expected to raise approximately £330 million per year, all of which would be returned to business through a 0.1% cut in employer National Insurance contributions together with a new Sustainability Fund to deliver environmental benefits. There was expected to be no net gain to the Exchequer.

The current rate for the Aggregates Levy is £2.00 per tonne.

### REVISION QUESTIONS

5. List four nuisances that must be adequately controlled on a landfill site, particularly if it is near a populated area.
6. Give three advantages and three disadvantages of:
   (a) Landfill.
   (b) Incineration.

(Suggested Answers are at the end.)

# Risks Associated with Contaminated Land

## KEY INFORMATION

- Land contaminated by industrial processes can have a number of harmful effects to humans, plants, animals and water.
- There are significant liabilities associated with contaminated land.

Land contaminated by industrial processes can have direct and indirect effects on human health. Contaminated land also brings with it significant liabilities for the owners of the land, even if they are not the producer of the contamination.

## THE POTENTIAL EFFECTS OF CONTAMINATED LAND TO THE ENVIRONMENT

Many industries have a significant potential to contaminate the land on which they operate. Some of the most common ones are:

- Mining and extractive industries.
- Iron and steel works.
- Oil refining and storage.
- Sewage treatment works.
- Chemical and pharmaceutical works.

## TOPIC FOCUS

**Effects of Contaminated Land**

The **hazards** associated with land contamination include:

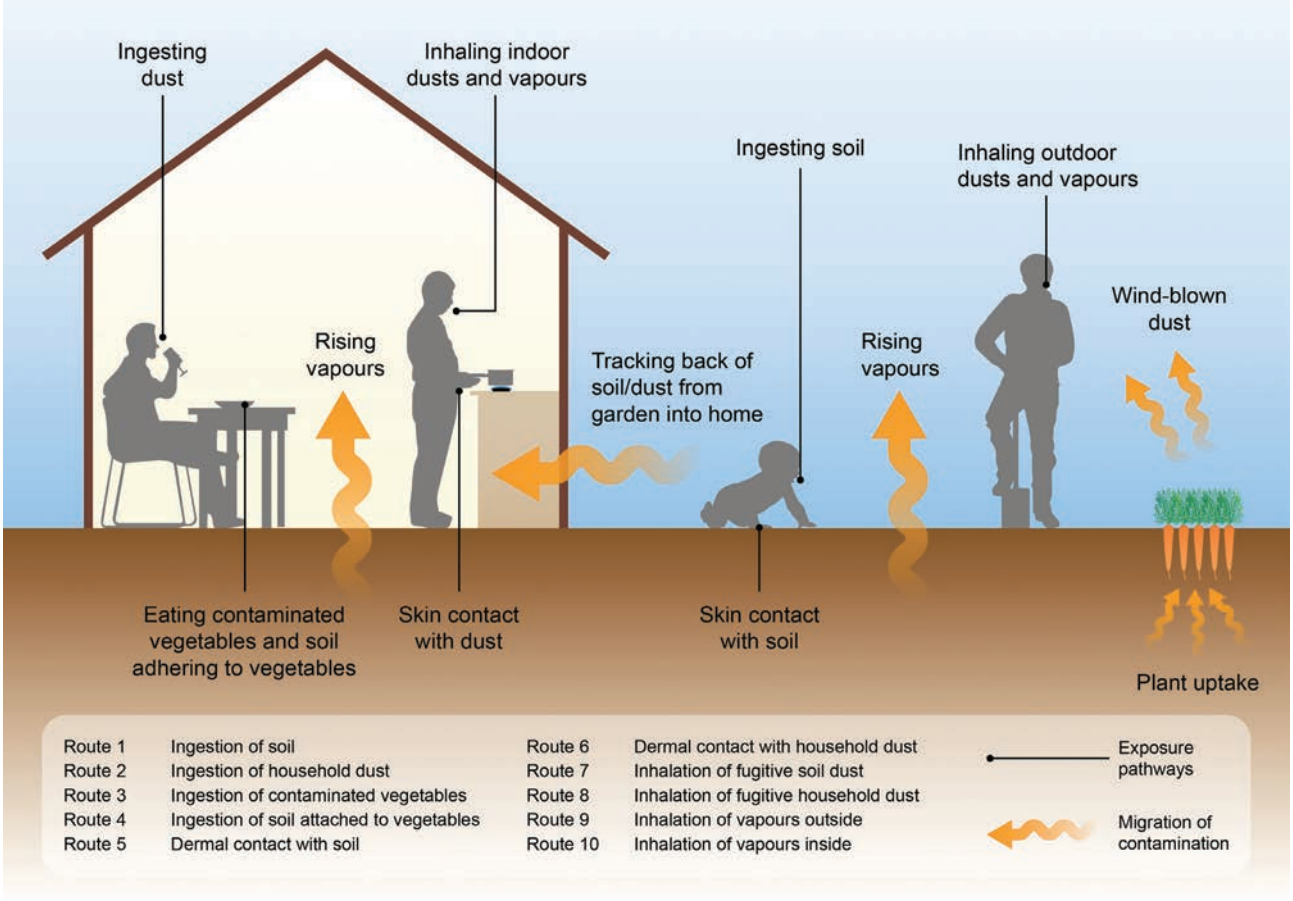
- Direct risk to human health by ingestion, particularly of toxic metals that accumulate in the body, e.g. lead and cadmium.
- Toxic substances entering the food chain through plant uptake.
- Water contamination:
  - Directly by migration through plastic water pipes (especially of phenols and cresols) into household water supplies.
  - Indirectly by leaching into groundwater.

(Continued)

## TOPIC FOCUS

- Prevention or inhibition of plant growth:
  - Phytotoxic (plant poisoning) contaminants may affect plant growth at low concentrations (e.g. toxic metals).
  - Gases may displace air from soil and impede growth.
- Odours, fumes and effluvia, particularly when gases (landfill gases) percolate the site.
- Fire and explosion:
  - Gas explosions from methane and petroleum vapours.
  - Underground fires (responsible for odour, fumes, etc. and ground subsidence).
- Direct contact with, or inhalation of, certain contaminants – solvents, corrosives, carcinogens, asbestos, etc. Inhalation of dust, vapours (phenols and other aromatic compounds) and toxic gases may add to exposure. Skin contact with coal-tar residues can cause dermatitis, tar warts and skin cancer.
- Building damage, e.g. high levels of sulphate, can occur downwind of brickworks, along with fluorine as dry deposition on land over many years.

When considering health effects to humans, there is a number of different pathways a contaminant can take, depending on the type of contaminant.




People may be exposed to contaminants by a number of pathways

## CONTAMINATED LAND LIABILITIES

Contaminated land, and any knock-on effects of the contamination, such as pollution of groundwater resources, can be difficult and expensive to remediate. Much land contamination has been caused historically, where the organisation responsible for causing the contamination no longer exists. Determining liabilities for remediation may therefore be complex.

The legal basis for liability for contaminated land in the UK is contained in Part 2A of the **Environmental Protection Act 1990**. Local authorities are required to make a strategic assessment of likely contaminated sites and to undertake more detailed inspections of the presence of contamination based on this. The authority must then undertake a risk assessment to understand the risks posed and must designate a site as being contaminated if:

- Significant harm is being caused to a human, or relevant non-human, receptor.
- There is a significant possibility of significant harm being caused to a human, or relevant non-human, receptor.
- Significant pollution of controlled waters is being caused.
- There is a possibility of significant pollution of controlled waters being caused.

Once land has been determined as contaminated land, the enforcing authority must consider how it should be remediated and, where appropriate, it must issue a remediation notice to require such remediation. The enforcing authority for the purposes of remediation may be the local authority which determined the land, or the Environment Agency.

Liability for complying with the remediation notice is determined taking into account a number of factors:

- The possibility of identifying the person (individual or corporation) responsible for causing the contamination.
- The history of contamination of the site – contamination may have been caused over different time periods, by a number of different persons.
- The current owner or owners of the land.

Understandably, many contaminated sites are complex and liability for remediation may be assigned to a 'liability group' of persons who are deemed to share some measure of individual responsibility.

## MORE...

DEFRA have produced statutory guidance on contaminated land which may be found at:

www.gov.uk/government/uploads/system/uploads/attachment_data/file/223705/pb13735cont-land-guidance.pdf

## REVISION QUESTIONS

7. In relation to land contamination, give an example each of how water can be directly and indirectly contaminated.
8. List the hazards associated with land contamination.

(Suggested Answers are at the end.)

## SUMMARY

This element has dealt with the control of waste and land use.

In particular, this element has:

- Outlined categories of waste, including:
  - Inert waste – waste which is "stable", e.g. uncontaminated bricks, glass, concrete, etc.
  - Hazardous waste – any waste that has a hazardous property (e.g. corrosive, carcinogenic or ecotoxic).
  - Non-hazardous waste – controlled waste that does not exhibit properties required to define it as hazardous.
  - Clinical waste – surgical swabs, dressings, animal tissue, etc.
  - Radioactive waste – waste that contains or is contaminated with radionuclides at concentrations or activities greater than clearance levels, as established by the regulatory body.
  - Controlled waste – waste controlled by relevant legislation in the UK.
- Explained the waste hierarchy: prevent its production, prepare products/components for re-use, recycle/compost, recover energy after some form of treatment, and responsible disposal.
- Shown how waste needs to be controlled all the way through the waste chain, for its source to site of final disposal.
- Outlined how waste should be appropriately separated, stored, identified and labelled at all times.
- Explained that waste should be transferred only to a waste carrier who is registered with a competent authority.
- Outlined how, in the EU, **Directive 94/62/EC on Packaging and Packaging Waste** and **Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE)** operate to prevent waste formation.
- Shown that construction sites generate significant quantities of waste.
- Described the outlets available for waste, including:
  - Landfill and incineration, both of which have advantages and disadvantages.
  - Other treatment and disposal methods, such as waste transfer stations and treatment facilities, involving recovery operations.
- Outlined how taxes can be applied to waste, with the aim of reducing the volume of waste going to landfill and making alternative options for disposal more financially viable (using UK taxes as an example).
- Explained that many industries contaminate the land on which they operate (e.g. mining and extractive industries, iron and steel works, oil refining and storage).

## QUESTION 1

(a) **Identify FOUR** categories of waste. (4)

(b) **Outline**:

(i) the advantages; (8)

(ii) the disadvantages; (8)

of sending waste to landfill sites.

## QUESTION 2

**Identify** how contaminated land can cause harm to the environment. (8)

### APPROACHING QUESTION 1

This is an example of a Section 1 question.

- Read the question.
- Consider the marks and time available (30 minutes).
- Highlight the key words.
- Read the question again.
- Produce a plan.

### SUGGESTED ANSWER

**Plan**

(a) 'Identify' question so no plan required.

(b) (i) Low cost, capacity, locality, power generation, visual impact, amenity value, wildlife.

(ii) Air pollution, leachate, hazardous nature, site shortage, hamper development of alternatives, jobs low paid, nuisance, cost.

**Answer**

(a) The categories of waste are controlled, inert, hazardous, non-hazardous, clinical and radioactive.

(b) (i) Landfilling of waste is currently a low cost way to deal with waste in comparison to other measures.

There is a large capacity for landfill sites to be built and operated in some areas.

A number of different waste types can be landfilled – this may include residues from other waste treatment processes which cannot be dealt with in any other way.

Waste produced locally can be dealt with close to the source of production, which will also provide employment for local people.

Landfill gas generated from the anaerobic decomposition of waste at a landfill site can be used as a fuel to generate power which can be used for heating, lighting, etc.

Well designed landfill sites can be unobtrusive, causing no or little visual impact, e.g. they can be screened from view by trees.

Sites that have been restored can have a high amenity value (can be used for leisure purposes).

Restored sites can also be valuable sites for local wildlife, such as birds.

(ii) Poorly designed, particularly older sites, can be sources of air pollution. For example, landfill gas consists largely of methane – a potent greenhouse gas.

Landfill sites may also emit a toxic-polluting liquid known as leachate. This can cause significant damage to surface water and groundwater.

Some landfill sites that have been poorly designed and operated are extremely dangerous with regard to humans and the environment and are classed as contaminated land. They may present a risk of fire and explosion.

In some areas, there is a shortage of sites that are suitable for landfill near to where the waste is generated, meaning that waste has to be transported long distances, causing further environmental impacts.

As landfill is an established and convenient method of waste management, it can reduce the development of alternative techniques that are more sustainable, e.g. recycling.

Jobs that are created are mainly low paid.

A landfill site is likely to be a significant source of nuisance to the local population due to odour and noise, etc.

The introduction of the **Landfill Directive** and increases in Landfill Tax mean that other methods of dealing with waste are becoming a more viable economic alternative.

## APPROACHING QUESTION 2

As before, using good exam technique you must:

- Read the question.
- Consider the marks and time available.
- Highlight the key words.
- Read the question again.

## SUGGESTED ANSWER

Now you have finished your answer, read the suggested answer below and compare it to your answer.

Any eight of the following:

- Direct contact with the land.
- Harm to people and animals through inhalation of gases or dust.
- Run-off of pollutants into surface water.
- Infiltration of pollutants into groundwater.
- Bioaccumulation of substances in crops, harming humans and animals when eaten.
- Damage to services and buildings as a result of corrosion.
- Methane accumulation causing explosion and climate change.
- Odour from the land, causing nuisance to local population.
- Visual impact of the land.

# SOURCES AND USE OF ENERGY AND ENERGY EFFICIENCY

ELEMENT 7

## LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Outline the benefits and limitations of fossil fuels.
2. Outline alternative sources of energy and their benefits and limitations.
3. Explain why energy efficiency is important to the business.
4. Outline the control measures available to enable energy efficiency.

# Contents

## KEY INFORMATION

- Fossil fuels are formed from the organic remains of marine micro-organisms (oil and gas) and land-based vegetation (coal).
- Advantages of fossil-fuel use include:
  - Easy combustion and transportation.
  - Fuels are relatively inexpensive.
  - Generation of electricity is efficient and inexpensive.
  - Power stations can be built anywhere.
- Disadvantages of fossil-fuel use include:
  - Environmental effects, including acid rain, climate change and damage from extraction.
  - Fuels are non-renewable.
  - Prices are variable depending on markets.
  - Emissions contribute to poor air quality.

### EXAMPLES OF FOSSIL FUELS

Coal, oil and gas are called fossil fuels for the simple reason that they are formed from the fossilised organic remains of plants:

- Marine micro-organisms in the case of oil and gas.
- Land-based vegetation in the case of coal.

The processes that gave rise to the current stores of oil, gas and coal began in the Carboniferous period of the Paleozoic Era some 360 to 286 million years ago.

## Formation of Oil and Gas

Oil and gas are derived from the accumulation of very large quantities of organic material on the floor of ancient oceans. The organic material mostly consisted of the remains of microscopic plants that lived in the upper layers of the oceans and captured carbon from atmospheric carbon dioxide dissolved in seawater through the process of photosynthesis. In some parts of the oceans, where the sea-floor was stagnant and deprived of oxygen, the remains of these dead organisms were not readily broken down, allowing layers to accumulate. A high-rate of sedimentation then ensured that the accumulations of dead organisms became rapidly buried.

As the sedimentation processes continued, the plant remains were subject to increasingly high pressures and temperatures converting the carbon contained in the dead tissues into oil and gas. Over time, these hydrocarbons migrated through porous rocks such as sandstones and accumulated in areas that were overlain by impervious strata. These pockets of hydrocarbons formed the oil and gas fields that we exploit today.

## Formation of Coal

Coal is formed through a very similar land-based process. Vegetation in low-lying, swampy conditions is the most likely to form deposits of coal. As with the production of oil and gas, a stagnant environment excludes oxygen and so reduces the breakdown of dead vegetation, allowing it to accumulate and to form peat. As this process continues, successive layers of peat are buried and eventually covered by sediments. This process of continual burial with the addition of heat over long periods of time breaks down and alters the hydrocarbons in the peat. The peat then goes through a number of stages, becoming richer in carbon at each stage, as other elements are dispersed from the original material. These stages are:

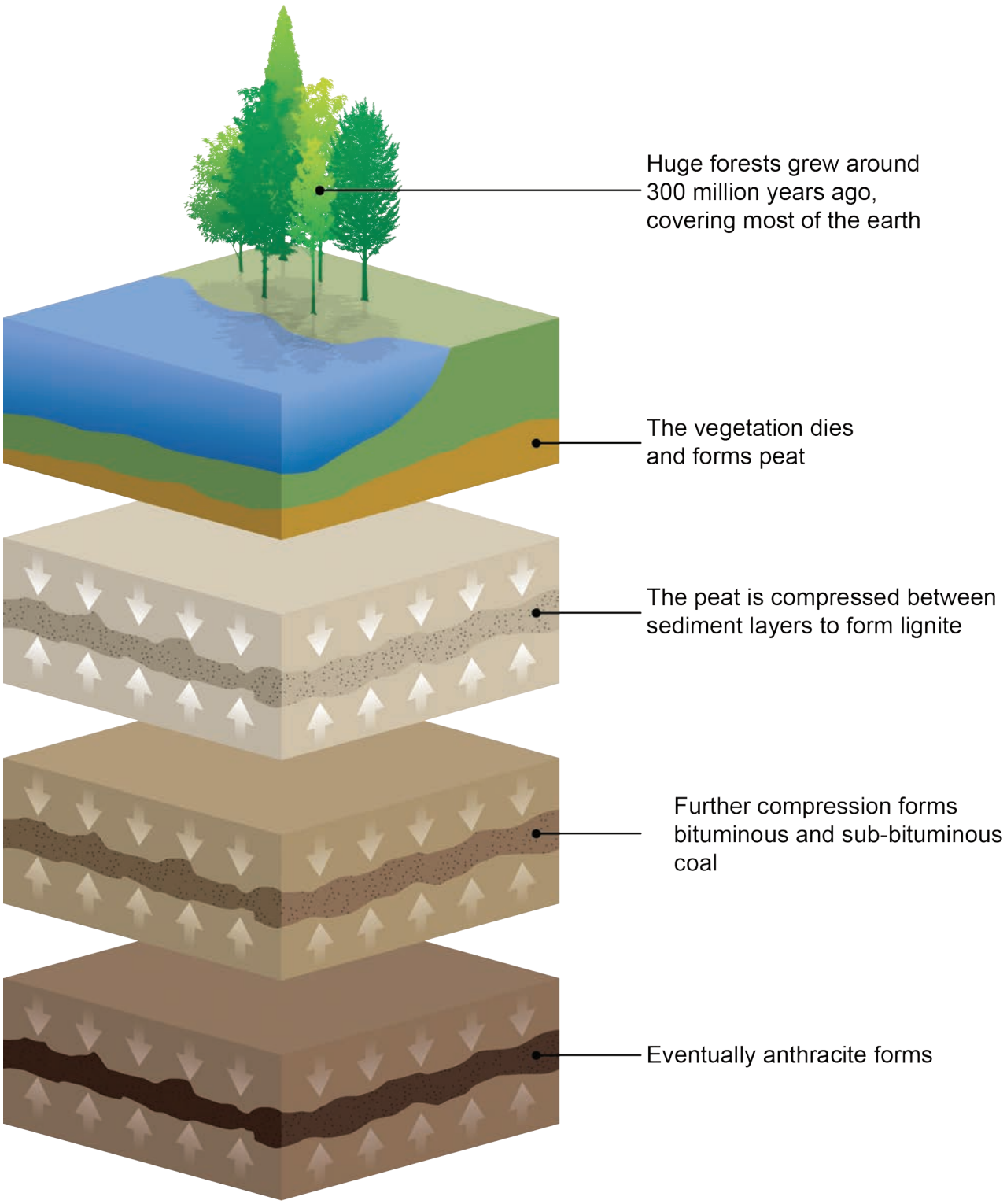
- Peat.
- Lignite.
- Sub-bituminous coal.
- Bituminous coal.
- Anthracite coal.
- Graphite (pure carbon).

## Common Fossil Fuels

The fossil fuels that are in common use today are:

| Fuel | Description |
|---|---|
| Coal | Solid, black carbon-based mineral.<br>The largest source of fuel for electricity generation worldwide. |
| Anthracite | Very high quality coal, with a carbon content >90%. |
| Lignite | Low quality 'brown coal', with a carbon content 60-70%. |
| Coke | Solid residue made by heating coal in the absence of air. Widely used in steel furnaces. |
| Petrol/Gasoline | Mixture of hydrocarbon compounds distilled from petroleum (crude oil) and containing various additives. The most common fuel for passenger road vehicles and aircraft. |
| Diesel/DERV | Mixture of hydrocarbon compounds distilled from petroleum but more dense than petrol.<br>The most common fuel for freight road vehicles.<br>Sometimes used to fuel boilers for space heating.<br>(Note that biodiesel is not fossil fuel.) |
| Fuel oil/Heating oil/Paraffin | Mixtures of hydrocarbon compounds distilled from petroleum.<br>Available in various grades.<br>Used to fuel domestic and industrial boilers and ships. |
| Natural gas | Naturally occurring hydrocarbon gas mostly consisting of methane.<br>Widely used for domestic and industrial heating and electricity generation. |
| LNG (Liquefied Natural Gas) | Natural gas condensed to a liquid for bulk transport by refrigerating to -162°C.<br>Converted back to gas before use as above. |
| LPG (Liquefied Petroleum Gas) | Propane or butane (or a mixture).<br>Used as a fuel in heating appliances, cookers and sometimes road vehicles. |

In certain countries, such as the Republic of Ireland, peat is also extracted on an industrial scale for use in electricity generation.




Fossil-fuel formation on land

## Where Supplies Come From

As you can see, very specific geological conditions are required for the formation of oil, gas and coal, so it is not surprising that deposits of fossil fuels are found in specific areas around the world. However, it is not just a question of where the deposits are that influences where the supplies come from. Other aspects are also significant, such as:

- Ease of access to the oil, gas or coal.
- How it can be transported from source to processing factory and finally to the consumer.

Clearly, oil and gas have an advantage over coal in that they can be transported by pipeline.

The table below shows the level of oil consumption and production of the top 20 nations by production.

Comparative Global Production and Consumption of Oil1

| Country | Production (%) | Consumption (%) |
|---|---|---|
| Oman | 1.3 | 0.1 |
| Libya | 1.9 | 0.3 |
| Indonesia | 1.9 | 1.4 |
| Algeria | 2 | 0.3 |
| Brazil | 2.1 | 2.9 |
| Iraq | 2.9 | 0.6 |
| Nigeria | 3 | 0.4 |
| Kuwait | 3 | 0.4 |
| UK | 3.4 | 2.3 |
| United Arab Emirates | 3.4 | 2.3 |
| Canada | 3.6 | 2.2 |
| Venezuela | 4.1 | 0.7 |
| European Union | 4.3 | 19.1 |
| China | 4.4 | 6 |
| Norway | 5.5 | 0.2 |
| Mexico | 4.8 | 2 |
| Iran | 5 | 1.7 |
| Russia | 9.7 | 3.4 |
| United States | 10.7 | 25.9 |
| Saudi Arabia | 11.6 | 1.9 |

[1]From *A Brief Guide to the End of Oil* by Paul Middleton

## BENEFITS AND LIMITATIONS OF THEIR USE AS AN ENERGY SOURCE

### Benefits

Since fossil fuels were first discovered, they have provided an ever increasingly important supply of energy. Our modern lifestyle would be impossible to maintain without the benefits that fossil fuels have provided. Coal was probably the first fossil fuel to be used regularly as a replacement for wood in cooking fires. In many areas of the world, low-grade coal could be found near to the surface and was therefore easy to access. The high-grade coals only became generally accessible with the invention of the steam-driven pump that could de-water deep mines where the better coal was to be found. Coal is still a major provider of energy for both domestic and industrial use. It is used in power stations to generate electricity and in manufacturing processes, such as cement manufacture.

Oil has a wide range of uses, such as energy production, and is a raw material for many everyday goods, such as plastics. Oil enables:

- Goods to be moved around the globe economically, so providing an ever-increasing range of consumer products for us to purchase.
- Access to cheap fuel, allowing many people to own and drive a car and have good quality food all year round in their local supermarket.

Compared to an alternative power source, such as nuclear, oil and coal are relatively safe and simple technologies. It is easy to build a coal- or oil-fired power station and relatively easy and cheap to transport the required fuel from point of production to point of use.

### Limitations

Although it is clear that there are many advantages to using fossil fuels, they are not without their limitations.

- The burning of fossil fuels is now believed to be a major contributor to climate change through the emission of large volumes of $CO_2$ to the atmosphere.
- Fossil fuels are known to contribute significantly in some areas to the production of acid rain that leads to damage to flora and fauna over large areas of land.
- The extraction of the raw materials often leads to significant damage to the environment.
- Oil spills from pipelines and tankers often impact highly sensitive areas for wildlife.


Warning of Oil Spill on Beach

The table below summarises the advantages and disadvantages of the use of fossil fuels.

Advantages and Disadvantages of Fossil-Fuel Use

| Advantages | Disadvantages |
|---|---|
| Straightforward combustion process. | Major contributor to climate change. |
| Relatively inexpensive. | Cause acid rain. |
| Easily transported. | Non-renewable resources that are not sustainable in the long-term. |
| Large amounts of electricity can be generated in one place, quite cheaply. | Prices are susceptible to changes in global politics so may rise significantly at short notice. |
| Gas-fired power stations relatively efficient. | Extracting the raw materials can be dangerous and damaging to the environment. |
| Power stations can be built almost anywhere. | Emissions may contribute to poor air quality locally, thereby affecting people's health. |

Not all fossil fuels are equal in their impact on the environment:

- Gas burns cleaner than oil and produces about twice the energy per kilo and proportionately less $CO_2$ when burnt.
- Different oil products also contribute differently to air pollution when burnt, e.g. petrol burns comparatively cleanly against the heavy fuel oil burnt in the shipping industry.
- Heavy oil and diesel produce a high volume of particulate matter that can have an adverse effect on both plant and animal (including human) life.

## REVISION QUESTION

1. List three advantages and three disadvantages of the use of fossil fuels.

(Suggested Answer is at the end.)

# Other Sources of Energy

## KEY INFORMATION

- Alternative sources of energy include: solar, wind, hydroelectric, wave, tidal power, geothermal, nuclear, combined heat and power, biodigesters, methane recovery and biomass.
- There are both benefits and limitations to the use of alternative energy sources.
- Problems can occur with energy generation and supply in developing countries and remote regions.

Alternatives to fossil fuel are being increasingly developed as energy sources for a number of reasons:

- There is concern over the effects of fossil-fuel use on the environment.
- Costs of fossil fuels are increasing.
- Demand for fossil fuels is starting to outstrip supply.

Here, we will look at some of the main alternative sources, although there are many other potential sources and many new ones being developed.

## SOLAR

Effectively, all energy on the planet originates with solar energy. Even fossil fuels originally gained the energy they stored through photosynthesis and respiration via energy from the sun. Humans have used direct solar energy for thousands of years to dry clothes and grow food. However, it is only recently that we have been using it to generate electricity. The sun produces far more energy than we require, so if we can develop efficient ways to capture that energy, many problems could be resolved.

There are three main ways in which we use solar power:

- **Solar cells** (photovoltaic or photoelectric) developed as a method of powering satellites. They are now a common way of generating power for both domestic and commercial properties in some parts of the world.

Photovoltaic cells

- **Solar water heating** uses energy from the sun is used to directly heat water in glass panels, thereby reducing the amount of energy from fossil fuels required to provide hot water for use in the house.
- **Solar furnaces** are commercial installations that use a large number of mirrors to concentrate the energy of the sun into a small space and to allow the production of very high temperatures. Some of these furnaces can produce temperatures up to 33,000°C.

A significant drawback of solar energy is that it is only effective during the hours of daylight, whereas peak energy consumption is often after nightfall, especially in the winter months. Large surface areas are also required for photovoltaic arrays and, as with wind power, this had led to concerns that renewable energy infrastructure is damaging the landscape and amenity value of previously undeveloped countryside.

## WIND

The use of wind as an energy supply is also not new:

- Wind was in use by the Babylonians and Chinese as long as 4,000 years ago to pump irrigation water.
- Windmills used for grinding corn were common in Europe in the Middle Ages.

Modern windmills are actually wind-powered turbines. They use the power of the wind to generate electricity. Wind-farms, as they have become known, are now a common sight.

## Wind-Farm Operation

- There needs to be an average wind speed of 25km/h for them to operate efficiently.
- At very high wind speeds, many wind turbines become less efficient or need to shut down to prevent damage occurring.
- Propellers of modern wind turbines are much larger than traditional windmills and are mounted much higher. This is to ensure they capture energy from the largest possible volume of air.
- The blades can have their pitch adjusted to increase the range of wind speeds in which they can operate and to maximise efficiency.
- The body of the turbine can be turned so the blades are always facing into the wind.

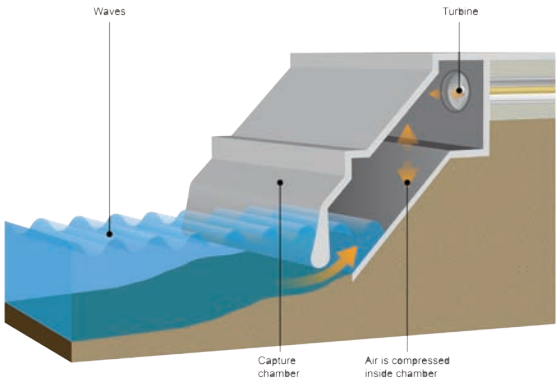
### HYDROELECTRIC

The most common type of hydroelectric energy generation uses the flow of water under gravity to turn a turbine attached to a generator. The generator converts the rotary mechanical motion into electricity. The water is usually held in a reservoir behind a dam. Hydroelectricity is extensively generated in Scotland, which has an abundance of the required natural resources.

Other methods of hydroelectricity generation use undershot waterwheels, utilising the flow of the water below a vertically-mounted wheel (like a water mill, only the mechanical energy is converted to electricity rather than being used directly).

### WAVE

Wave power generation is still rare as it is difficult to harness the energy of the waves. One of the most common ways of generating power from waves is through the use of an air chamber and turbine connected to a generator. The following figure shows how the waves make the water in the chamber move up and down. The movement of air drives the wind turbine and that, in turn, drives the generator.




Example of a wave turbine generator

### TIDAL POWER

Tidal power uses the energy of rising and receding tides to generate power. Although large amounts of power could be generated in this way, tidal power schemes are rare because the technological barriers are significant.

## Tidal Power Operation

- The system is similar to a hydroelectric power station using the movement of water to drive a turbine.
- A dam or barrage needs to be built across a river estuary to focus the power of the tide.
- As the tide comes in, water moves from the seaward side to the estuary side of the barrage.
- The turbine inside the barrage is driven by the power of the water.

### GEOTHERMAL

As we go down through the Earth, the temperature increases to a point where rocks become molten. In general, the temperature increases by 1°C every 36 metres in depth. The origin of the heat is continuous radioactive decay deep inside the Earth. It is possible to use this heat to generate electricity.

## Geothermal Operation

- Holes are drilled down until they reach a depth where the temperature is hot enough to boil water.
- Pipes are then installed in these wells and water is pumped down the pipes.
- As the water turns to steam it drives a turbine that is connected to a generator and produces electricity.

Effective exploitation of geothermal energy is really only feasible in particular regions, where geological conditions are favourable; for example, volcanic areas such as Iceland.

### NUCLEAR

Nuclear power uses the heat from radioactive processes to generate steam that is used to power turbine-driven electricity generators. Nuclear fission of radioactive isotopes of uranium is currently the most common source of energy in nuclear power stations, although some fuel uses other metals, such as plutonium. Nuclear power stations provided about 13% of the world's electricity in 2012.

An important advantage of nuclear power is that relatively small amounts of fuel produce a lot of power. Also, the output from nuclear power stations is very reliable and not weather-dependent, as is the case with other fossil-fuel alternatives, such as wind and solar.

One of the most compelling arguments in support of nuclear power is that it has a very low carbon footprint – each kWh of nuclear electricity has about the same level of carbon emissions as a kWh of electricity produced by wind power. Many observers therefore see nuclear as an important route to combating global warming.

The main drawback of nuclear power stations is that they generate significant volumes of potentially dangerous radioactive waste. Power station operations result in:

- Large volumes of waste with a low-level of radioactivity, such as contaminated protective clothing and equipment.
- Significant volumes of waste with a high-level of radioactivity from the re-processing of spent fuel. These typically contain radioactive isotopes of metals, such as technetium, iodine, neptunium and plutonium. These materials are highly dangerous to living organisms and have half-lives of tens of thousands, or even millions of years, which means that they require long-term secure storage.

Accidents at nuclear power stations also have the potential to release radioactivity into the surrounding environment. For example, mechanical failures can result in losses of cooling gases or liquids that are contaminated with radioactivity. More serious failures in reactor cooling systems can result in catastrophic fires that release very large amounts of high-level radiation that can be transported hundreds of miles in the atmosphere.

Although accidents at nuclear power stations are rare, a number of high-profile incidents have occurred, for example:

- Chernobyl, Ukraine, 1986: a catastrophic reactor fire sent a plume of highly radioactive fallout into the atmosphere that contaminated large areas of Belarus, Ukraine and Russia and led to the evacuation of around 350,000 people.
- Fukushima, Japan, 2011: the combined effects of an earthquake and a tsunami resulted in failure of the cooling system for six reactors, which caused significant pollution with radioactive contaminated water.

Despite their reliability and weather independence, nuclear power stations are not very flexible in terms of the ability to vary their output to meet immediate changes in power demand. Nuclear power stations work most efficiently when they produce a steady level of output over a long period and are therefore more suited to contributing to the 'base-load' of electricity demand.

Nuclear power stations are also expensive and time-consuming to construct and to decommission at end of life. These issues, coupled with widely held opposition to nuclear power on safety grounds, have greatly hindered the further expansion of nuclear power in developed countries. For example, Italy has banned nuclear power stations and Germany has declared that its existing nuclear plants will close by 2022. Nevertheless, some governments remain committed to nuclear power; for example, over 80% of electricity in France is nuclear generated and China has an on-going and substantial programme for constructing new nuclear power stations.

## GLOSSARY

### NUCLEAR FISSION

This involves 'splitting the atom'. The energy used to hold the atom together is released in the form of heat.

## COMBINED HEAT AND POWER (CHP)

Combined Heat and Power (CHP) is the generation of usable heat and power (usually electricity) in a single process.

CHP systems can be employed over a wide range of sizes, applications, fuels and technologies. In its simplest form, CHP employs a gas turbine, engine or steam turbine to drive an alternator and the resulting electricity can be used either wholly or partially on site, with any excess being supplied to the national grid system. The heat produced during power generation is recovered, usually in a heat recovery boiler, and can be used to raise steam for a number of industrial processes, to provide hot water for space heating or, with appropriate equipment installed, cooling.

Because CHP systems make extensive use of the heat produced during the electricity generation process, they can achieve overall efficiencies in excess of 70% at the point of use. In contrast, the efficiency of conventional coal-fired and gas-fired power stations, which discard this heat, is typically around 38% and 48% respectively. Efficiency at the point of use is lower still because of the losses that occur during transmission and distribution.

CHP is a form of decentralised energy technology. CHP systems are typically installed on site, supplying customers with heat and power directly at the point of use and therefore helping to avoid the significant losses which occur in transmitting electricity from large centralised plant to the customer.

## BIODIGESTERS

As the name implies, biodigesters use bacteria to break down organic matter (such as pig manure). Anaerobic conditions are maintained in these digesters, the action of the bacteria producing biogas, composed mainly of methane and carbon dioxide but with some hydrogen sulphide. After purification, the methane can be used as a fuel, in the same way that conventional domestic gas is used. Depending on the sophistication of the biodigester (there are numerous commercial designs), other by-products of the process that can be extracted include recycled water (but not suitable for drinking!) and high-grade fertiliser.

### GLOSSARY

**ANAEROBIC CONDITIONS**

Low oxygen levels.

## METHANE RECOVERY

Biodigesters, discussed above, are a form of 'methane recovery' in the wider sense but this is a term most commonly associated with landfill sites. Much of the waste sent to landfill is organic and biodegradable. The action of bacteria under the anaerobic conditions in landfill sites produces 'landfill gas', which is largely methane (around 50-60%). Methane is a potent greenhouse gas and also flammable. It can therefore:

- Contribute to global warming.
- Present a risk of explosion either at the landfill site itself or at local residential areas (as it seeps through the ground laterally and vertically).

However, if it is collected, it can be used directly for fuel and to generate electricity in 'gas-to-energy' projects (using engines/turbines). The recovered energy can either be used for running the operations at the landfill site alone or for the local community, or exported.

The landfill gas is typically collected by sinking a series of vertical wells into the landfill site. These wells are connected via pipelines and the gas is drawn off (with the aid of a vacuum system) to a collection point for purification (using a scrubber) and processing (such as compression, combustion in an engine generator and hence conversion to electricity).

## BIOMASS

In addition to wood, a number of agricultural crops are increasingly being grown specifically to generate biomass for use as fuel, including special grasses (Miscanthus) and hemp. Simple sugars from crops, such as sugar cane and sugar beet, can also be fermented to produce ethanol, which can be used either directly as a fuel or as an additive in petrol, e.g. fuel containing up to 5% bioethanol is now widely available in the UK.

Vegetable oils from crops, such as rapeseed, can also be converted to biodiesel through the chemical process of transesterification. The use of land for growing energy crops rather than food, however, is controversial, especially in developing countries that may experience food shortages. As with any agricultural crop, high inputs of artificial fertilisers may also be used to generate high yields and may result in negative environmental impacts – especially diffuse pollution of watercourses with nitrates.

## BENEFITS AND LIMITATIONS OF THE USE OF ALTERNATIVE ENERGY SOURCES

Alternative energy sources clearly have many benefits to offer, many of which they have in common. However, they also have limitations.

## TOPIC FOCUS

**Benefits and Limitations of Alternative Energy Sources**

All alternative energy sources have the benefit of:

- Reduced or zero $CO_2$ production and therefore:
  - Reduced adverse impact on the environment.
  - Less contribution to climate change.
- Being 'renewable' or 'comparatively renewable' (except nuclear).

Other benefits and limitations are summarised in the table below:

| Alternative Energy Source | Benefits | Limitations |
|---|---|---|
| Solar | • Remote areas.<br>• Close to where energy is required.<br>• No emissions. | • Unable to control how much and when.<br>• No power generation at night. |
| Wind | • No emissions.<br>• Remote areas.<br>• Free form of motive power.<br>• Small-scale operation as a local source of energy.<br>• Plant can be prefabricated off site. | • Unable to control how much and when.<br>• Only generates power when there is wind.<br>• Susceptible to damage in very strong winds (over 25m/sec).<br>• Noise generated by turbines.<br>• Loss of visual amenity.<br>• Construction and maintenance costs can be significant.<br>• Have to be large to provide sufficient energy for large-scale demand.<br>• Remote from demand means that long supply cables required with subsequent energy transmission loss.<br>• Objections by some to turbines. |
| Hydroelectric | • Dams and reservoirs provide additional recreational resources.<br>• Long useful life of plant. | • Construction and loss of habitat (e.g. by flooding valleys).<br>• Reservoirs can generate methane from anaerobic decomposition (tropical regions). |
| Wave and Tidal Power | • No emissions.<br>• No waste products.<br>• Limited running costs. | • Unable to control how much.<br>• Only produce power when there is wave or tidal action.<br>• Ensuring the generator and associated equipment remain anchored in place. |
| Geothermal | • No emissions to air.<br>• Remote locations.<br>• Reliable fuel source. | • Often relatively large amounts of land required. |

(Continued)

## TOPIC FOCUS

| Alternative Energy Source | Benefits | Limitations |
|---|---|---|
| Nuclear | • Relatively small amounts of fuel produce a lot of power.<br>• Output is reliable and not weather-dependent.<br>• Very low emissions of carbon dioxide and other greenhouse gases. | • Generates significant volumes of potentially dangerous radioactive wastes.<br>• Expensive and time-consuming to construct and decommission.<br>• Inflexible in terms of the ability to 'turn on and off' in response to changing power demands.<br>• High-profile accidents have created a significant degree of public and political opposition. |
| Combined Heat and Power (CHP) | • Efficient method for utilising both fossil and renewable fuels.<br>• Highly efficient.<br>• Usually generated at the point of use. | • Emissions to air.<br>• Loss of visual amenity.<br>• Transport of fuels to site. |
| Biodigesters | • Organic matter decomposes naturally – biodigesters utilise a waste product.<br>• Relatively low cost. | • Possible odour problems.<br>• $CO_2$ is still produced when methane is burnt. This, although less potent, is still a greenhouse gas. |
| Methane Recovery | • Methane is generated by landfill sites as part of the decomposition process.<br>• Reliable source of fuel from a landfill as it is produced for many years even after closure.<br>• Low cost. | • Uncollected methane is a greenhouse gas and presents a risk of explosion.<br>• $CO_2$ is still produced when methane is burnt. This, although less potent, is still a greenhouse gas. |
| Biomass | • Renewable resource.<br>• Biomass crops can be grown widely in many locations. | • Uses land that could be used for growing food.<br>• Indirect pollution associated with high inputs of artificial fertilisers. |

## ENERGY SUPPLY IN REMOTE REGIONS AND DEVELOPING COUNTRIES

Developing countries face an important challenge in providing modern energy services to help alleviate extreme poverty and meet other societal development goals. However, emissions from developing countries are growing rapidly and make a significant contribution to environmental issues, such as poor air quality and climate change, presenting a serious risk to the environment and human health.

In some parts of the world, cutting wood for burning also leads to significant deforestation and burning this wood in inefficient, old-fashioned stoves leads to emissions of smoke having a significant impact on local air quality. It is a key challenge to provide sustainable energy to developing countries and remote regions that is clean and yet reliable.

## REVISION QUESTIONS

2. List the three main ways in which we use solar power.
3. What is CHP?

(Suggested Answers are at the end.)

## KEY INFORMATION

- Energy efficiency can achieve both reductions in greenhouse gas emissions and financial savings in energy bills.
- Reducing emissions of $CO_2$ and other greenhouse gases is essential to prevent or reduce the effects of climate change.
- The process of peak load management is often used by energy suppliers.

There is now a strong focus on the need to reduce energy consumption as well as develop new ways to provide it.

Clearly, if we do not use as much energy, then less needs to be generated and therefore the environmental impact is reduced. Even the renewable energy supplies discussed above have some environmental impact from the:

- Production of the equipment.
- Need to travel to maintain it.
- Energy used in these activities.

It should therefore be clear that improving energy efficiency should be at the top of any hierarchy of controls regarding energy use.

### REDUCTIONS IN CARBON DIOXIDE EMISSIONS

$CO_2$ is considered to be a major contributor to climate change. Reducing emissions of $CO_2$ and other greenhouse gases is essential if the detrimental effects of climate change are to be prevented or reduced. Some of the main control measures available are discussed in more detail in the next section of this element. These are:

- Insulation to prevent heat loss.
- Choice of equipment – type of fuel used, efficiency of the equipment.
- Maintenance to ensure it remains efficient.
- Adequate control systems so equipment is only active when required and only using the amount of power required.
- Providing suitable information, instruction, training and supervision to those who will operate the equipment.

### SAVINGS IN ENERGY BILLS AND PEAK LOAD MANAGEMENT

Peak load management is a process often used by utility suppliers to manage the peak load required. Any user of electricity can use peak load management in conjunction with their electricity provider to assist with the management of power supplies, although it is most commonly used by heavy industry and large commercial users.

## GLOSSARY

**PEAK LOAD/PEAK DEMAND**

Terms used interchangeably to denote the maximum power requirement of a system at a given time, or the amount of power required to supply customers at times when need is greatest.

Many industrial users of electricity will sign up to an agreement to reduce power demands during peak periods. The customer gets a reduced price overall but pays a large penalty if they fail to reduce power usage when required to do so by the utility company.

## REVISION QUESTION

4. Define 'Peak Load' and 'Peak Demand'.

(Suggested Answer is at the end.)

# Control Measures Available to Enable Energy Efficiency

## KEY INFORMATION

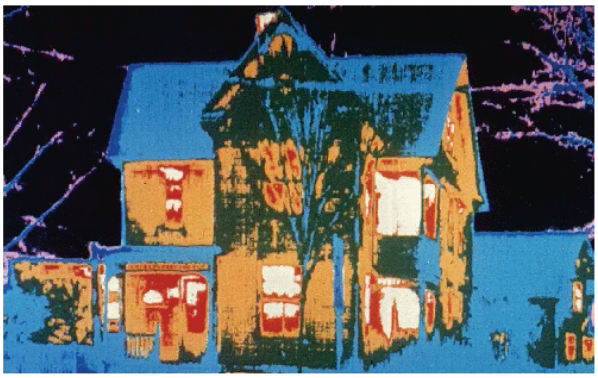
- There are a number of key measures to improve energy efficiency, including:
  - Insulation.
  - Choice of energy-efficient equipment and vehicles.
  - Maintenance and control of system.
  - Supervision and training.
  - Building design.
  - Car sharing.
  - Optimisation of vehicle use.
  - Teleconferencing.

There is a number of control measures available to manage and reduce energy use. None of these is likely to provide a full solution to the issue of energy management within an organisation. There must be an objective assessment of where energy is being used and/or lost or used inefficiently, so that a suitable combination of controls can be implemented and any spending required can be targeted effectively. Such a system of energy management can be found in **ISO 50001:2011** *Energy Management Systems*, which sets standards for measurement, documenting, reporting, design/procurement practices for systems and people that contribute to energy performance.

## INSULATION

Effective insulation is a medium-cost measure that can usually be implemented relatively easily. Common insulation techniques are loft- or roof-space insulation and cavity wall insulation. These can be as effective on commercial premises as they are on domestic homes.

The following image and table show the difference that good quality insulation can make in reducing heat losses from an ordinary house. In the thermographic image, the dark areas show the least amount of heat loss, while the white areas show the most heat loss.



Thermographic image showing heat loss from a house

Difference in Heat Loss Between Insulated and Uninsulated House

| Route | % Heat Loss from Uninsulated House | % Heat Loss from Insulated House |
|---|---|---|
| Roof | 25% | 5% |
| Walls | 35% | 10% |
| Doors | 10% | 5% |
| Floor | 10% | 5% |
| Windows | 20% | 10% |

There are many EU Directives that cover energy usage and performance – for example, **Directive 2010/31/EU on the Energy Performance of Buildings**, the principal objectives of which are to promote the:

- Improvement of the energy performance of buildings within the EU through cost-effective measures.
- Convergence of building standards towards those of member states which already have ambitious levels.

## MORE...

More information on practical steps that can be taken by organisations to improve energy efficiency is available from the following sources:

www.carbontrust.com/resources/guides/energy-efficiency/employee-awareness-and-office-energy-efficiency

www.carbontrust.com/client-services/technology/innovation/industrial-energy-efficiency-accelerator

## CHOICE OF EQUIPMENT

Choosing the right equipment is likely to have a major impact on energy consumption. For instance, electric motors must be matched to the demand required of them:

- Buying one that is too small will mean it is running at full capacity most of the time and is likely to require more current.
- One that is over-sized will be running at too low a capacity and therefore not running efficiently.

If lighting systems are to be changed or installed in new buildings, designing the system correctly and installing the right equipment can ensure significant savings over the life of the building. The common causes of wasted energy with regard to lighting systems are:

- Lights being used unnecessarily.
- Lighting unoccupied buildings or rooms.
- Using lights when daylight provides sufficient light levels.

Significant savings can be made through the use of low energy lighting. Taking the standard tungsten halogen bulb as 100%, the table below shows potential savings:

Comparison of Low Energy Light Sources Against Standard Tungsten Filament Bulb

| Lamp Type | Relative Energy Consumption as % |
|---|---|
| Tungsten halogen spotlight | 70 |
| Compact fluorescent with electronic ballast | 18 |
| Metal halide | 15 |
| High-pressure sodium | 11 |
| 16mm fluorescent tube (T5) with electronic ballast | <12 |

## MAINTENANCE AND CONTROL SYSTEMS

A system will only remain operating efficiently if it is properly maintained. Whether it is servicing heating boilers, or ensuring lights are cleaned regularly, the same principles apply. An effective Planned Preventative Maintenance system will help avoid expensive and inconvenient breakdowns and should, over time, reduce the operating costs as the equipment is kept in the most efficient operating condition.

## Heating

Unless heating equipment is very old and unreliable, consideration should be given to improving the control of existing systems before the purchase of new equipment is considered.

There are three main types of controls for heating systems:

- **Simple switches** – may be manual or automatic and simply switch equipment on or off. Automatic switches can be used to preset the time at which the heating will turn on and off.
- **Complex time switches** – will often be able to compare indoor and outdoor temperatures and be set to bring a building up to a certain temperature by a specific time. This is especially useful where buildings such as offices are not occupied over night but occupants do not want to come in to a cold building. With correct control systems, the start time can be varied depending on outside conditions.
- **Continuous controllers** – these will constantly monitor and adjust the system to maintain an even temperature within defined limits. They are likely to be more complex to set up, but also the most efficient system.

A modern Building Energy Management System (BEMS) can significantly reduce the energy used to heat and cool a building. It also has the advantage that it is usually controlled centrally and so is less likely to be misused with temperatures set too high or too low. A centralised system also allows a more consistent temperature throughout a building, preventing the situation where different sections of a system are conflicting with each other to maintain a set point temperature.

## Lighting

Lighting systems account for a significant amount of energy used in most buildings, and the fitting of suitable control systems can play a major role in reducing this energy consumption. There are two main categories of lighting controls:

- **Manual** – the simple on/off switch we are all familiar with. Proper labelling allows people to know which lights can be switched off when not required. Combined with the correct layout, so the layout of the switches matches that of the lights, this means people are more likely to switch off those lights not required. Significant savings are possible if lights are switched in rows running parallel to the windows and lights nearest the windows can be switched off separately from those further away.
- **Automatic** – controls such as timers and sensors can be used to automatically turn off lights when not required. Sensors can be for movement or light levels but the best systems combine the two. This way, even when people are in the room, if light levels are sufficient, the lights will not be switched on. It is important that automatic controls are set correctly to ensure that people are not left in darkness; this involves correct positioning of the sensors, correct sensitivity of sensors and correct timing before lights are switched off. This is especially important where people may not be moving around the room all the time and it may be necessary to have a manual override available.

Occupancy sensors can also be used in other applications, such as urinal flush control. The system would be able to control lighting, ventilation and flushing relative to occupancy and therefore produce savings in energy and water.

Illuminated buildings will have significant energy use

## INITIATIVES

Energy efficiency initiatives can be a positive way to reduce energy consumption in an organisation. Initiatives can be launched at a global level (by international co-operation) as well as at national, regional and company level. For example, in June 2008, the G8 nations established the International Partnership for Energy Efficiency Co-operation. It is anticipated that this will lead to concrete actions (e.g. through public-private partnerships).

At a local level, initiatives may be poster campaigns focused on specific issues, such as switching off unused equipment and lighting. Many offices now have large numbers of computers and, while it may not be desirable to keep switching off the PC itself, the monitor can usually be turned off easily and quickly, therefore saving a considerable amount of the energy used by the PC.

If these initiatives are to be successful, it is important to be aware of the reasons why many fail:

- Insufficient top-level support – visible and real commitment is required from senior managers. This may range from the switching off of unwanted appliances, to ensuring budgets are available for training and that staff are released to attend the training.
- Funding – if significant savings are identified but require funding, then suitable funding must be available. Some energy reduction measures require almost no investment, such as switching off equipment. However, there may be a case for investing in new equipment or new controls for existing equipment.
- Inadequate resources – there will inevitably be many issues and questions raised by the implementation of an energy efficiency programme. Suitable resources in terms of time and equipment should be allocated to deal with these issues.
- Lack of co-ordination across an organisation – failure will be more likely if different strategies are followed by different parts of an organisation, as staff may well be confused about what they are supposed to be doing. If this occurs, they will likely default to doing what they have always done in the past.
- Lack of targeting – it is important to identify where the biggest gains can be made first. In a large industrial organisation, major savings may be made through investment in new equipment or training in managing existing equipment. For instance, conveyor belts are often left running while empty, thereby consuming large amounts of energy. Focusing on getting these switched off when they are not required will achieve far greater savings than fitting automatic light switches in the offices.

## INFORMATION, INSTRUCTION, TRAINING AND SUPERVISION

Measures such as insulating buildings, ensuring optimum control systems and ensuring the right equipment, are likely to prove to be ineffective if the staff who use the building or the equipment are not provided with the right information, instruction, training and supervision. It is important to understand the difference between these requirements:

- **Information** – can be provided verbally or in written format; it may be through the use of posters, notices on payslips, memos or e-mails, etc. Information is often one-way communication in that it requires no specific and direct response, and there are often no checks to ensure the information has been successfully received.
- **Instructions** – usually given by a senior person to a more junior person in the organisation. May be written or verbal but should be clear and unambiguous about what is required of the person being instructed.
- **Training** – is more involved than simply passing information from one person to another. There should be clear aims and objectives about what the training will achieve and some means of checking that those objectives have been achieved and that learning has taken place. This would usually be through either an exam or some form of continuous assessment.
- **Supervision** – where a more qualified or senior person actually observes the work that is or has been done and ensures it is to the correct standard. With the development of 'flatter' organisations, i.e. fewer levels of management, levels of supervision in many organisations are lower than they would have been in the past. This gives increased importance to ensuring staff are competent through the provision of information, instruction and training.

## TOPIC FOCUS

In summary, there is a number of actions an organisation can take to **enable energy efficiency within a building**:

- Monitoring energy use to identify areas of excessive usage.
- Insulation of buildings.
- Choice of the right equipment, including appropriate motor sizes and energy-efficient light bulbs where appropriate.
- Implementation of planned preventive maintenance to ensure systems and equipment operate at optimum efficiency.
- Implementation of control systems, such as heating controllers, automatic lighting switches.
- Ensuring staff are informed, instructed, trained and, most importantly, supervised to ensure energy efficiency measures are implemented and followed.

## BUILDING DESIGN

Considering energy efficiency at the design stage is key in making buildings more energy efficient. For example, natural ventilation (rather than ventilation forced by a fan) can lead to considerable energy savings. Fresh air is required in buildings to provide oxygen, prevent odours and increase thermal comfort. Natural ventilation can be achieved in numerous ways, such as using openable windows or trickle vents. More complex methods include designing buildings to allow warm air to move upwards to upper openings; this will force cool air to be drawn in from outside. In very warm climates, natural ventilation may not always be possible and more conventional air conditioning systems will be needed.

Another design option is to provide passive solar heating, which uses windows, floors and walls to collect and distribute heat during cool periods and reject heat during hot periods. This is a passive system as it does not involve any mechanical or electrical equipment. It takes advantage of the climate in the location of the building. Elements often considered in such systems in temperate regions include:

- Windows facing the midday sun in winter and being shaded in the summer.
- Reducing windows on other sides.
- Using suitable insulation to reduce seasonal excessive heat loss and gain.
- Using thermal mass (the ability of the building to soak up heat before it reaches the interior during the day and release it at night).

## FUEL CHOICE FOR TRANSPORT AND THE OPTIMISATION OF VEHICLE USE

For many organisations, transport represents a significant proportion of their energy consumption. This is especially so if the travel for staff getting to and from work is taken into account. There is now a number of different fuel sources available for transport and here we take a look at some of the more common ones as well as other ways to reduce energy use associated with transport.

- **Petrol and diesel** – still the most common transport fuel for most people and goods; produced from oil and very commonly available. The burning of petrol and diesel produces oxides of sulphur and nitrogen along with carbon monoxide, carbon dioxide and VOCs, and has been identified as one of the most significant contributors to climate change and air pollution. Diesel has an advantage, in that it is generally more efficient than petrol, resulting in reduced fuel consumption for comparable vehicles. However, it also produces more particulates and sooty emissions than petrol so is often seen to be 'dirtier' than petrol.
- **LPG** – the use of Liquefied Petroleum Gas (LPG) (a mixture of propane and butane produced as a by-product of oil and gas production) has seen a steady increase around the world. Most cars which have been converted to run on LPG can also run on petrol; this is necessary due to the limited number of fuel stations providing LPG. It is not as efficient as petrol in that some loss of power is often found in comparison to the same engine running on petrol. However, it is currently around half the price of petrol and the emissions are significantly cleaner than those from a similar petrol engine, with fewer particulates and some 15% reduced $CO_2$ emissions.
- **Electric** – all-electric vehicles have also seen an increase in popularity, although this is mainly in cities where speeds are low and driving distances relatively short. Although some test electric vehicles have produced speeds up to 60mph and possibly more, most commercially available vehicles are limited to about 40mph and a range of perhaps 60 miles before they need recharging. This is usually done via a normal household socket and can take several hours. Electric cars are impractical for most people, although in some commercial uses they can be extremely effective.
- **Hybrid power** – these vehicles use a combination of an internal combustion engine (usually petrol) linked to an electric motor. The electric motor assists the petrol engine, thereby allowing a smaller petrol engine to be used and reducing fuel consumption; at the same time, the batteries for the electric motor are recharged by the petrol engine. At very low speeds, the electric engine can power the vehicle completely for short distances. The benefits of this type of vehicle depend largely on the type of driving being undertaken. During high-speed motorway driving, the fuel consumption is not significantly different from that of an efficient diesel engine. However, if much of the driving is around towns and cities, this type of vehicle can prove very efficient.
- **Biofuels** – championed as the saviour of the environment for many years, the benefits of biofuels are now being questioned by many environmental organisations. Produced from crops such as rapeseed and palm oil, it is now clear that first-generation biofuels (those produced directly from crops as opposed to the use of second-hand oils such as used cooking oil) are not $CO_2$ neutral and may be more harmful than ordinary oil products. There is great concern regarding the diversion of crops away from the production of food to the production of vehicle fuels, thereby adding to food shortages in many parts of the developing world.

Other ways to reduce energy consumption related to travel are often termed "Green Travel Plans". These plans involve an organisation looking at how employees travel to, from and during work and ways to reduce the dependence on cars. This could be by:

- Working with local bus companies to change routes or timetables.
- Providing incentives, for example:
  - Interest-free loans for rail season tickets.
  - The 'cycle to work' scheme supported by some governments, where employers can offer interest-free loans to purchase a bicycle to get to and from work. This allows an employee to either purchase a better bicycle or spend less on the same bicycle they would have bought.
- Employee car-sharing schemes – experience has shown that it is quite difficult to get people to initially sign up for such schemes but, once signed up, they use them enthusiastically. It is noteworthy that when fuel prices increase dramatically, so does the popularity of these schemes.

- Training staff in efficient driving, for example:
  - Under-inflated tyres and roof racks increase fuel consumption.
  - Avoiding sharp acceleration and braking reduces fuel consumption.
  - Planning journeys to reduce the amount of time spent in congestion will reduce fuel consumption.
- Use of technologies such as teleconferencing or video conferencing, which may eliminate (or at least reduce) the need for travel.

## TOPIC FOCUS

In summary, the key measures an organisation can introduce to **reduce energy consumption associated with transport** include:

- Choice of appropriate fuels.
- Car sharing.
- Financial incentives to cycle to work or use alternative transport modes.
- Planning travel outside peak times.
- Training staff in efficient driving behaviour.
- Working with local bus companies to change routes or times of buses.
- Use of technology such as teleconferencing rather than travel.

## REVISION QUESTION

5. Explain some of the reasons why energy efficiency initiatives fail.

(Suggested Answer is at the end.)

# Summary

## SUMMARY

This element has dealt with the sources of energy and energy efficiency.

In particular, this element has:

- Outlined how fossil fuels (coal, oil and gas) are formed from the organic remains of marine micro-organisms (oil and gas), and land-based vegetation (coal).
- Explained the benefits of the use of fossil fuels as an energy source, including: a straightforward combustion process; relatively inexpensive; easily transported, etc.
- Highlighted the limitations of fossil fuels: major contributors to climate change, cause acid rain, use a non-renewable source of energy, prices fluctuate according to world politics, etc.
- Discussed other sources of energy including: solar, wind, wave and tidal power, geothermal, nuclear, Combined Heat and Power (CHP), biodigesters, methane recovery and biomass.
- Outlined the problems associated with energy generation and supply in developing countries and remote regions.
- Explained that the benefits of alternative energy sources include reduced or zero $CO_2$ production, and the possibility of generating power in remote areas or close to where power is required. Generally, they are cleaner systems with few emissions at the point of generation.
- Shown that renewable sources (e.g. wind, wave, tidal and solar power) have a limitation in that they are out of our control in terms of how much power they will generate and when. Disadvantages of nuclear power are problems of acceptance of site location and long-term secure storage requirements for waste materials.
- Explained that a significant result of energy efficiency will be a reduction in $CO_2$ emissions. In addition, savings in energy bills can be achieved by using peak load management (particularly important for industrial users).
- Discussed control measures available to manage and reduce energy use, including:
  - Insulation to prevent heat loss.
  - Choice of equipment: type of fuel used, efficiency of the equipment.
  - Maintenance: to ensure equipment remains efficient.
  - Adequate equipment control systems.
  - Providing information, instruction and training to those using the equipment.
  - Building design.
- Outlined how organisations should review their transport use (travel to work and for work purposes) and ensure they choose from the various fuel sources available with protection of the environment in mind.

## QUESTION 1


**Outline EIGHT** measures that can be implemented to reduce the financial cost of energy. (8)

## QUESTION 2

(a) **Identify FOUR** methods of energy generation that do not involve fossil fuels. (4)
(b) **Outline** the reasons why other forms of energy should be considered. (4)

### APPROACHING QUESTION 1

As before, using good exam technique you must:

- Read the question.
- Consider the marks and time available.
- Highlight the key words.
- Read the question again.
- Write a plan.

Note that this question asks for ways to reduce costs, so your answer can contain improvements that do not necessarily reduce environmental impact.

### SUGGESTED ANSWER TO QUESTION 1

**Plan**

Design, maintenance, lighting, switch-off scheme, alternatives sources, peak load management, transportation, insulation, energy management (any eight of these).

**Answer**

Any eight of the following:

- The initial design and choice of equipment for the task is important. Purchasing equipment with reduced energy consumption in comparison with present inefficient equipment will reduce costs in the long term.
- Equipment will also need to be maintained so that it continues to work effectively. Electrical costs can be minimised by lighting controls, such as fitting motion sensors in corridors or other relevant areas.
- Compact fluorescent lights and other more efficient light types could also be fitted. The use of high-energy-rated equipment will also reduce consumption and cost. Lights that have a high energy rating should be purchased by the organisation.
- The organisation could also implement a switch-off scheme – this might include provision of labels, posters and basic training to staff to switch lights and equipment off when not in use.
- The use of alternative forms of energy should also be considered. Combined heat and power will, for example, make use of waste heat from power generation which could be used to heat a building.
- Peak load management could also be used as this will ensure that an organisation pays less for its energy if it uses less at peak times.
- Costs could also be saved through improvement in transportation with fuel type, effective route planning and training of drivers all leading to potential cost reductions.
- Insulation of pipework and buildings and not heating areas that are unoccupied can also lead to cost reductions.
- Employing an energy management company to look at energy consumption for a large site, including supplier and tariff analysis, can also significantly reduce costs associated with energy.

## APPROACHING QUESTION 2

Remember:

| | |
|---|---|
| • Read the question.<br>• Consider the marks and time available.<br>• Highlight the key words. | • Read the question again.<br>• Write a plan for part (b). |

## SUGGESTED ANSWER TO QUESTION 2

**Plan for Part (b)**

Dependency, carbon dioxide, acidic gases, cost reduction, energy security, impacts of extraction and distribution, innovation (any four).

**Answer**

(a) Four out of the following: solar heat or electricity (e.g. from photovoltaic cells); wind turbines; hydropower; wave and tidal power; geothermal energy; nuclear power; biomass; biofuels.

(b) Any four from the following:

- To reduce dependency on fossil fuels. Fossil fuels such as coal, oil and gas are non-renewable and will run out at some point in the future, so alternative sources of energy must be found to replace them in the long term.
- Burning fossil fuels releases carbon dioxide into the air. Carbon dioxide is an important greenhouse gas that causes climate change.
- The burning of fossil fuels emits acidic gases such as sulphur and nitrogen oxides. Such gases cause poor local air quality due to their irritant properties and are also involved in the formation of photochemical smog. Such substances can also cause acid deposition.
- Alternatives can have the ability to reduce costs (particularly if supported by grants). Wind, for example, is free and renewable, although generation equipment will require finance.
- As large quantities of oil, coal and gas are sourced from overseas, using alternative techniques to produce energy in a particular country will mean that the country's energy supplies are much more secure than the current situation.
- Fossil fuels have an environmental impact when being extracted or distributed. For example, many oil spills have occurred during the shipping of oil, causing serious pollution incidents.
- The promotion of alternative forms of energy will lead to a greater level of innovation. Such innovation can lead to growth in the renewable energy sector, leading to well paid technical jobs.

# CONTROL OF ENVIRONMENTAL NOISE

ELEMENT 8

## LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Describe the potential sources of environmental noise and their consequences.
2. Outline the methods available for the control of environmental noise.

# Contents

# Sources of Environmental Noise and their Consequences

## KEY INFORMATION

- Environmental noise emanates from a number of sources including: industry; road traffic; leisure activities; and domestic neighbouring properties.
- Low frequency noise is associated with effects such as nausea, headaches and feelings of anxiety.
- Unreasonable environmental noise, in law, may be either a statutory or a common law nuisance. It may lead to loss of sleep, anxiety and stress.
- Noise can cause disturbance to local wildlife.

## THE CHARACTERISTICS OF NOISE WHICH LEAD TO IT BEING A NUISANCE

Noise may be defined as unwanted sound. People exposed to very high levels of noise, for example from machinery and equipment in enclosed spaces, can suffer damage to their hearing, and this is a recognised occupational health issue. But noise can also be unwanted because it causes disturbance or annoyance. Most people will have experienced unwanted noise that interferes with life at home or perhaps has prevented a good night's sleep in a hotel room. Noise from a wide variety of sources can travel considerable distances and affect the peace and enjoyment of life. This type of noise is referred to as **environmental noise**, or **noise nuisance**.

Noise emanates from a wide range of man-made sources, including:

- Industrial premises.
- Transportation systems.
- Construction sites.
- Agricultural activities.
- Aeroplanes.
- Entertainment and leisure establishments.
- The homes of neighbouring residents.

The perception of noise can be quite subjective. A particular noise may be acceptable to one person, but very annoying to another. The main factors that affect the perception of noise are:

- **Loudness**: loud noise is likely to be more intrusive.
- **Pitch**: low-pitched (or 'low frequency') sound, e.g. from heavy machinery or the bass from entertainment sound systems, can travel substantial distances. Pulsating low-pitched sound was a particular problem with early wind turbine designs and may also be associated with heavy road traffic.
- **Incidence**: noise that happens only occasionally may be tolerable, but regular noise may be anticipated by people who are affected, leading to a greater sense of annoyance and anxiety.
- **Background levels**: a given sound will travel further and be more noticeable in areas that are generally peaceful, such as the countryside, than in a busy city street.

Complaints about noise are growing. Many complaints of neighbourhood noise arise as a result of:

- Anti-social behaviour.
- Poor planning controls.
- The juxtaposition of incompatible land uses.
- Specific one-off events, such as clay pigeon shooting, burglar and theft alarms (especially their repeated, intermittent, high-frequency nature), fireworks, explosives, parties or the use of a jack-hammer on a road surface.
- Sirens or other noise interfering with use of tannoy systems for communication.

As we saw in Element 1, unreasonable noise is considered a nuisance.

## The Effects of Noise

Noise nuisance can affect the quality of life in a number of ways, by:

- Being intrusive and annoying.
- Resulting in severe lack of sleep.
- Producing headaches and nausea.
- In extreme cases, causing anxiety, stress and depression.

Environmental noise may also affect wildlife. Wild animals may be disturbed and prevented from feeding in certain areas because of man-made noise. Certain animals – notably birds – use complex calls to communicate with other members of the same species, especially during breeding. Man-made noise can interfere with these communication systems.

| Measurement in dB(A) | Sound |
|---|---|
| 0 | The faintest audible sounds |
| 20-30 | A quiet library |
| 50-60 | A conversation |
| 65-75 | A loud radio |
| 90-100 | A power drill |
| 140 | A jet aircraft taking off 25m away |

Typical decibel levels associated with different noise sources

## GLOSSARY

### db(A)

Noise is measured in decibels (dB). The human ear is, however, more sensitive at the frequencies of 1 kHz to 4 kHz. When the noise is measured, the equipment is adjusted to best represent the way the human ear hears it (dB(A)).

## SOURCES OF INDUSTRIAL ENVIRONMENTAL NOISE

### Manufacturing and Related Commercial Activities

Manufacturing activities, especially traditional heavy industries, may generate significant noise from:

- Pressing and forging metal parts (e.g. shipyards and vehicle assembly plants).
- Turbines (e.g. electricity generation plants).
- General machinery (e.g. motors, grinding and planning, air compressors, conveyor systems).
- Extraction systems (e.g. motors, fans).
- Public address systems (e.g. in warehouses and distribution centres).

The main problems arise when domestic premises or institutions, such as schools and hospitals, are located in close proximity to industrial facilities. This is less likely to occur nowadays, with the demise of many traditional heavy industries and the application of modern planning regulations.

### Transport Noise

Road traffic, especially heavy trucks, generate considerable noise from:

- Engines.
- Movement over road surfaces, especially from the bodywork of empty vehicles.
- The use of horns.
- Reversing alarms which are often high-pitched and can travel substantial distances.

Large jet aircraft engines are intensely noisy, especially during take-off and landing at airports.

Road traffic is a major source of noise in city centres; even in rural areas, noise from motorways can be detected several miles away, especially during the night time. Particular problems can be experienced where distribution centres that operate around the clock are located in close proximity to residential areas.

Noise around major airports, especially associated with plans for the development of new airports, has become a significant political issue.

### Agricultural Noise

Modern agriculture is highly mechanised. Noise from agricultural activities is often associated with the use of:

- Mobile machinery, e.g. tractors and harvesters, especially when harvesting is undertaken around the clock.
- Bird-scarers that simulate loud gunshots.

Any source of noise may be more noticeable in the countryside, because background noise levels are generally lower than in an urban environment.

### Construction Noise

Construction work typically involves activities that are potentially noisy, including:

- The use of heavy equipment, such as excavators and cranes.
- Pile driving, especially at larger sites.
- The use of powered tools, such as drills.
- Trucks and vans delivering materials and removing debris.

Construction work often takes place near town centres and in residential areas, and is a major source of environmental noise complaints. A balance often needs to be struck between the needs of the developer in completing the construction project and the avoidance of unacceptable disturbance to local residents.

Construction and demolition can cause substantial environmental noise

## Quarrying and Mining

The extraction of minerals from the ground also involves activities that are potentially very noisy, including:

- Operation of excavation machinery.
- The use of explosives.
- Operation of rock-crushing equipment.
- Operation of conveyor systems.
- Movements of heavy vehicles on and off site.

Quarrying and mining can be an important source of noise nuisance in rural areas.

**MORE...**

Further information and advice about noise nuisance can be found from the following sources:

noisenuisance.org

www.nidirect.gov.uk/noise-nuisance-and-neighbours

www.gov.uk/report-noise-pollution-to-council

# OTHER SOURCES OF NOISE

## Noise from Pubs and Clubs

Noise nuisance may be caused by the operation of sound systems at clubs, discotheques and open-air festivals or by people arriving and leaving. Noise may equally cause problems to residents in proximity to sporting events, such as motor car racing circuits, or open-air music concerts which are often located in quiet, rural areas.

Limits may be set in relation to the:

- Number of times such events are permitted.
- Distance from noise-sensitive premises.
- Amplitude of music from loudspeakers.
- Time and duration of such events.

## Neighbour Noise

Environmental noise is most likely to disturb us in our own homes. Noise nuisance is often created by the activities of other residents in the neighbourhood. Sources of noise that commonly cause annoyance include:

- Loud music from radios and other sound systems.
- Televisions.
- Use of equipment such as power drills, lawn mowers and strimmers.
- Dogs barking persistently or late at night.

Noisy neighbours is a problem that is increasingly being dealt with by local authorities and can be exacerbated by:

- People living closer together.
- Modern construction techniques providing limited sound insulation.
- Ever decreasing levels of social tolerance.

## Intruder and Vehicle Alarms

Noise from all intruder alarms can be a nuisance.

The standards for intruder alarms often relate to how the alarms are activated, to ensure few false alarms and the silencing of any siren after a period of time (usually 20 minutes).

## Wind Farms

The construction phase of a wind farm can lead to significantly high noise levels. These will result from the construction activities considered earlier.

Older designs of wind farms sometimes created a low-pitched pulsating noise that could travel significant distances. However, noise from the operation of modern wind turbines is usually minimal.

## Rural Noise

As we have briefly mentioned, noise nuisance is not restricted to busy urban environments. Noise nuisance can be a significant problem for the residents of rural areas. Whilst overall noise levels are likely to be higher in urban environments, individual noises may be more noticeable in the countryside. Sources of rural noise nuisance include:

- Mobile farm machinery, especially during harvest time.
- The operation of bird-scarers.
- Noise from motorways and railway lines that traverse the countryside.
- Mining and quarrying activities that are typically located in rural areas.
- Animals with loud and persistent calls, such as dogs, cockerels and peacocks.
- Open-air festivals and motor racing circuits.

## European Union Controls on Noise

**Directive 2002/49/EC** (the **Environmental Noise Directive**) relates to assessment and management of environmental noise. It sets the following requirements for member states:

- Member states must draw up strategic noise management plans. Inform and consult with the public on noise exposure its impacts and measures used to control it.
- Draw up action plans to reduce noise where necessary.
- Develop long-term EU strategy.

### MORE...

Further details about **Directive 2002/49/EC** are available at:

ec.europa.eu/environment/noise/directive.htm

### REVISION QUESTION

1. List five different sources of potential noise nuisance.

(Suggested Answer is at the end.)

## KEY INFORMATION

- Noise control techniques include physical controls such as: isolation, absorption, insulation, damping, and silencing.
- Management controls may also be implemented, covering hours of working, vehicle routes, etc.

## BASIC NOISE CONTROL TECHNIQUES

Wherever noise is a problem, the order of priority for dealing with it is:

- **Noise reduction at source** – e.g. by elimination or substitution of the process or equipment producing the noise.
- **Attenuation in transmission** – by engineering controls that limit the amount of noise transmitted.
- **Protection of the receiver** – e.g. through the use of double-glazing and the design of houses with living rooms and bedrooms away from roads.

### Elimination, Substitution and Maintenance

Noise can often be eliminated or reduced by replacing noisy equipment or processes with alternative, quieter equipment or processes. For example:

- Diesel/petrol engines replaced by electric motors.
- Pneumatic tools replaced by electric tools.
- Solid wheels replaced by pneumatic rubber tyres.
- Metal chutes, buckets or boxes replaced by rubber or plastic ones.

Many machines are noisy because of worn parts, poor maintenance, inadequate lubrication, or because they are 'out of balance'. Planned maintenance, replacement of worn parts and regular oiling will reduce noise and increase efficiency.

Rather than replace a complete machine or process, it may be possible to carry out a simple modification, e.g. plastic or rubber-coated rollers and guides on a conveyor belt may be used for handling glass or metal components.

### Isolation

In many cases, the best method of noise control is to enclose the noise source. Machinery enclosures should:

- Have a heavy, noise-reflecting outer skin.
- Have a noise-absorbent lining, such as mineral fibre.
- Be mounted so that they do not transmit noise and vibrations to the floor.
- Be airtight – the smallest gap allows sound to escape and reduces the attenuation of the noise inside the enclosure. This is a particular problem with, for example, woodwork machines, such as saws and planes, where timber is fed in at one end and comes out at the other. Such equipment can, however, be fitted with noise-reducing feed and delivery tunnels which should be lined with noise absorption materials and fitted with windows to allow clear viewing, and with adequate lighting.

### Absorption and Insulation

Machines are often situated in large, acoustically reverberant areas which reflect sound and build up noise levels within the room. Noise levels in adjacent rooms can be reduced significantly by using sound-absorbing materials on walls and other large surfaces. The absorptive surfaces reduce the reverberant component of the overall sound and, consequently, the level of noise in general.

As well as possessing absorbent properties, noise screens or enclosures and havens must be acoustically insulating. This means that they must transmit very little noise and therefore tend to be heavy. The superficial density of the barrier must be high.

### Environmental Noise Barriers

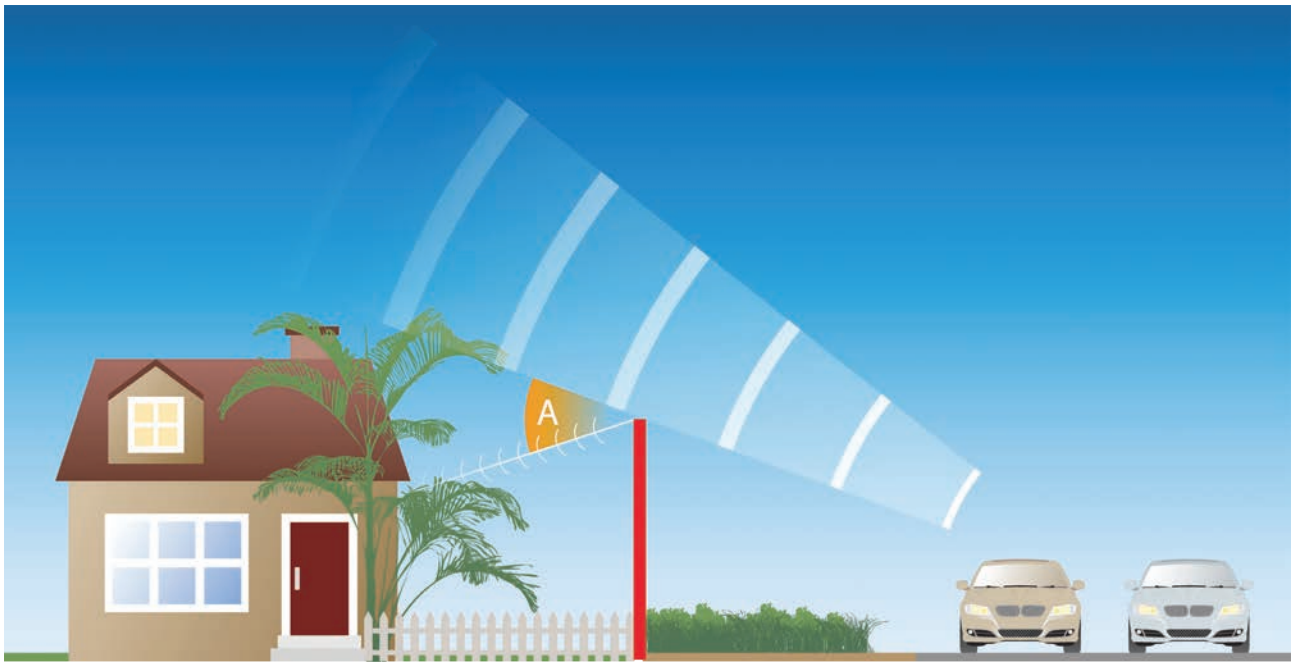
Screening the noise source is a common way of preventing noise spread. Suitable barriers could be:

- High walls or fences.
- Purpose-built earth berms or bunds.
- Other buildings in the vicinity of the noise source.

Although noise in some ways resembles the behaviour of light, in others it does not, and noise can be refracted round obstacles, literally travelling round corners. Therefore, hiding a piece of noisy equipment from view will not stop the noise.

Placing a barrier, such as a wall or fence, will only have a limited effect. This is particularly the case with low-frequency sounds. High-pitched noises tend to behave more like light and can be screened more effectively.

Screens may reduce noise from a small piece of equipment by preventing the noise escaping in a particular direction. Screens should be placed near to the source; the greater the angle, the better the noise reduction. Such a screen could reduce noise by 5 to 10 dB.




An acoustic barrier (which should be close to the source and as high as possible, to increase angle 'A' for more noise reduction)

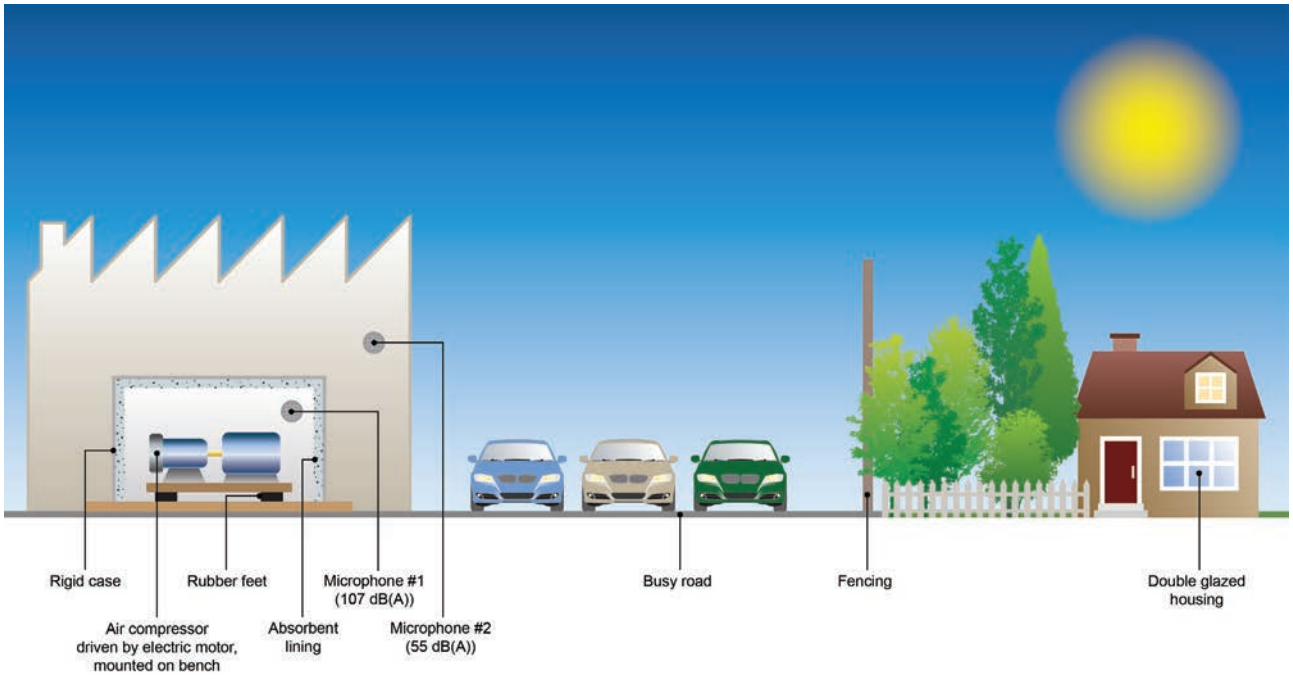
## Damping

Vibration is one of the main causes of noise. These vibrations can be transmitted from the source, via a rigid connection, to a variety of sites, such as the panels of a machine, floors, walls and tables. These large surfaces act as sounding boards and increase the level of noise.

The simple expedient of isolating the machine on anti-vibration dampers or rubber mountings may reduce noise levels considerably, e.g. putting rubber feet around the legs of machines. Other damping techniques include construction methods using bolts rather than welds and surface coatings or bonding applied to sheet metal.

## Silencing

Certain types of equipment involving the intake or discharge of air or other gases may be fitted with acoustic silencers, similar to the way in which gunshot sounds or the noise from car exhausts may be prevented. These work by absorbing the sound pressure generated by the process at its source.




Some methods of controlling noise

## Management Controls

Management controls are potentially more effective than the physical controls described above as, if implemented effectively, they will prevent the production of noise in the first instance and so move the controls up the hierarchy of control discussed above.

Examples of management controls are:

- **Control of working hours** – usually to reasonable daytime hours. Most people are out and busy during the day and, because there is more general activity taking place, individual noise sources are less likely to cause a problem.
- **Controlling the use of radios** (both music and two-way radios) – radios used for communication and entertainment can cause a nuisance to others nearby. Controlling the number of radios on a site and the volume they are played at is essential. When using two-way radios, the use of earpieces has advantages; they:
  - Prevent others hearing conversations and therefore any potential to cause a nuisance.
  - Improve the ability of the user to hear what is being said over the radio.
- **Public address systems** – should be designed so that sound is directed where it needs to be heard and not beyond the boundaries. This may mean using more, smaller speakers and being able to reduce the volume at night when background noise levels are generally lower.
- **Vehicle routes** – vehicles entering and leaving premises, especially large goods vehicles using air brakes and often air-assisted gear changes, can create significant noise levels. Proper routeing of these vehicles, together with signage indicating any prohibited areas or routes, can reduce the nuisance caused. Driver training can also have a significant positive effect.
- **Loading doors and shutters** – ensuring these are kept closed when not in use, especially during the night, can significantly reduce the noise levels and the potential for nuisance.

### REVISION QUESTION

2. Give three examples of management controls in relation to noise.

(Suggested Answer is at the end.)

# Summary

## SUMMARY

This element has dealt with the control of environmental noise.

In particular, this element has:

- Described noise as unwanted sound. Low-frequency sounds can travel long distances and have been associated with ill-health effects, such as nausea, headaches and anxiety. Other nuisances include tannoy systems and uncontrolled sirens.
- Discussed sources of industrial environmental noise, such as:
  - Noise from commercial activities, including machinery, extraction systems, compressor systems and public address systems.
  - Transport noise, e.g. engine noise, use of horns and reversing signals.
  - Agricultural noise, e.g. complaints relating to tractors, machinery and bird-scarers.
  - Construction noise, e.g. erection, construction, alteration, repair or maintenance of buildings, structures and roads.
  - Quarrying and mining.
- Outlined other sources of noise, including:
  - Noise from pubs and clubs.
  - Noisy neighbours.
  - Intruder and vehicle alarms.
  - Wind farms.
- Described methods for the control of environmental noise, including:
  - Elimination, substitution (replace diesel/petrol engine with electric motor) and maintenance (replacement of worn parts/regular oiling).
  - Isolation, by enclosing the noise source.
  - Absorption and insulation, by using sound-absorbing materials on walls and other large surfaces.
  - Environmental noise barriers, placed in the right position.
  - Damping, by using anti-vibration dampers or rubber mountings.
  - Silencing, by the use of silencers which absorb the sound pressure generated by the process at its source.
  - Management controls, e.g. control of working hours, use of radios, public address systems, vehicle routes, loading doors and shutters.


## QUESTION 1

A fan and collector hopper used to collect wood dust is to be installed against an outside wall of a furniture factory.

(a) **Identify TWO** potential sources of noise from the fan and hopper. (2)

(b) **Outline** the issues that should be addressed to ensure that the fan and hopper do not cause a noise nuisance to the local community. (6)

## QUESTION 2

(a) **Identify FIVE** potential activities that may lead to environmental noise. (5)

(b) **Identify** the potential impacts that noise could have on people and the environment. (3)

### APPROACHING QUESTION 1

Remember:

- Read the question.
- Consider the marks and time available.
- Highlight the key words.
- Read the question again.
- Write a plan for part (b).

### SUGGESTED ANSWER TO QUESTION 1

**Plan for Part (b)**

Equipment choice, maintenance, location, time of day, attenuation techniques, monitoring.

**Answer**

(a) Any two from: the motor and fan; vibration of the equipment, including grills and ducting; the discharge point.

(b) The correct equipment for the task should be chosen. This would include an evaluation of the noise levels of the whole system, taking into account proximity to sensitive receptors.

The fan and collector hopper would also need to be subject to regular preventive maintenance. Lack of lubrication or worn bearings or other parts could be a significant noise source.

The location of the equipment will also be important. Locating the equipment away from sensitive receptors, such as residents of surrounding housing, will result in less chance of nuisance occurring.

The time of day of the operation of the unit will also be important. The fan is more likely to cause a nuisance if operated at night, due to low levels of background noise and the increased likelihood of people being in their homes.

The noise could be attenuated by using techniques such as sound insulation, vibration mountings and screening by enclosures.

A regular monitoring regime could also be implemented. This would also assist in determining whether the unit is the actual source of the noise, should a complaint arise.

### APPROACHING QUESTION 2

Remember:

- Read the question.
- Consider the marks and time available.
- Highlight the key words.
- Read the question again.

### SUGGESTED ANSWER TO QUESTION 2

Now you have finished your answer, read the suggested answer below and compare it to your answer.

(a) Any five from the following: road traffic, airports, construction work, agricultural activities (e.g. tractor use, bird-scarers), factories, entertainment (e.g. pubs and clubs), noisy neighbours, burglar alarms, vehicle alarms.

(b) Examples include: human health, such as sleep deprivation, stress, high blood pressure, hearing damage, heart disease; disruption of wildlife (e.g. nesting or breeding birds); causing a public or private nuisance; structural damage to buildings (at specific intensities and frequencies) (any three).

# PLANNING FOR AND DEALING WITH ENVIRONMENTAL EMERGENCIES

ELEMENT 9

## LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content by applying what you have learnt to familiar and unfamiliar situations. In particular, you should be able to:

1. Explain why emergency preparedness and response is essential to protect the environment.

2. Describe the measures that need to be in place when planning for emergencies.

# Contents

## KEY INFORMATION

- There is a general duty or responsibility not to pollute the environment, so emergency plans should include procedures to control environmental hazards.
- A prompt response during an emergency can substantially reduce the environmental consequences of the incident.
- Strict liability is sometimes placed on organisations in relation to environmental damage. This means that the enforcing authority does not need to prove intent or negligence to successfully prosecute.
- Poorly managed environmental incidents usually require extensive and expensive clean-up and the reputation of an organisation can be seriously impacted.

We have already seen (in Element 5) that unplanned incidents can result in significant environmental impacts. For example, the Deepwater Horizon oil spill that took place in 2010 in the waters of the Gulf of Mexico was caused by an explosion on an oil exploration rig, and resulted in a massive oil spill that contaminated marine and coastal ecosystems for hundreds of miles. Thankfully, emergencies that result in major environmental impacts are rare, but minor emergency incidents, such as small spillages of fuel, are quite common and a significant source of local pollution.

The first responsibility of any organisation in the event of an emergency is to protect human life. But the risk of a major, or minor, emergency causing knock-on environmental impacts can also be greatly reduced by good planning and management. Emergencies that have the greatest potential to result in environmental impacts include:

- Fire. They may result in hazardous materials being released into the atmosphere, or washed into watercourses by fire hoses being used to extinguish the fire.
- Spillages. Many organisations store fuel and other hazardous liquids, such as chemicals. Losses of hazardous liquids can occur in circumstances such as:
  - When a tanker is delivering fuel and the delivery hose leaks, or the receiving tank overflows.
  - Decanting a liquid from one container to another by hand.
  - If a storage tank or pipeline becomes corroded and leaks.
  - A vehicle, such as a forklift truck, collides with tanks or drums.
- Flooding. Rising flood waters flowing across a site may wash hazardous materials onto adjacent land or into local watercourses.
- Plant failure. If pollution abatement equipment breaks down or malfunctions, emissions and discharges may fail to meet regulatory limits. Failures in process plant may also create pollution.

All these and many other emergencies not only have the potential to threaten human life, but also to impact adversely on the environment.

### GENERAL DUTY OR RESPONSIBILITY NOT TO POLLUTE

An organisation has a general duty or responsibility not to pollute the environment, so even if the primary concern is the protection of people, an emergency plan should include the environmental hazards and procedures to control them.

All organisations should have emergency plans in place. The size, complexity and primary aim of these plans will vary depending on the size and nature of the organisation. Office-based companies may have relatively simple plans with a primary aim of protecting life and ensuring the business is able to continue following the emergency.

### PART OF THE ENVIRONMENTAL MANAGEMENT SYSTEM

Any Environmental Management System (EMS) should identify the significant aspects and impacts that can arise from the organisation's operations, and this should include potential impacts under emergency conditions. **ISO 14001** also requires an organisation to:

- develop and maintain documented processes to identify and respond to accidents and emergencies; and
- prevent or reduce environmental impacts that are associated with them.

Identifying potential emergencies during the development of the EMS allows the procedures to be communicated, along with those for the normal and abnormal situations, and this helps to ensure that employees are fully aware of the requirements.

## NEED FOR PROMPT ACTION TO PROTECT PEOPLE AND THE ENVIRONMENT

During an emergency, there are usually a lot of different things happening at once and quickly. An emergency is a fluid situation; full information is often not known at the start of the incident. Nevertheless, situations have to be recognised and evaluated quickly and decisions made to mitigate potential consequences. For example, drains may have to be blocked and valves closed to stop a spillage escaping from a site into controlled waters. The middle of an emergency is not the time to have to make critical decisions that have not been considered beforehand. There is usually very little time to start finding new information, such as to where certain drains run.

The emergency services will not arrive immediately. There is therefore a window where prompt action may significantly reduce the potential environmental damage. We will look at emergency preparedness/planning in more detail later.

## RISKS OF PROSECUTION AND OTHER COSTS

Emergency situations are clear evidence that somewhere, something has gone wrong – either there has been equipment failure or someone has made a mistake. Regulatory regimes for environmental protection often impose a strict liability on organisations for the damage they cause to the environment. This means that it is not necessary for the regulating authority to prove any intent or negligence on the part of the organisation, but merely to show that they caused the damage:

- In some cases, fines can be unlimited. There is also the possibility of an individual being prosecuted and, if found guilty, facing a custodial sentence.
- Clean-up costs may also be awarded against the organisation that has caused the damage. In some cases, these may be considerably higher than the fine itself.
- Civil claims may be made by those who have suffered some loss as a result of the incident.

The combination of criminal fines, clean-up costs and compensation may be sufficient to put an organisation out of business, even without the consequent loss of income an environmental incident can incur.

## REPUTATIONAL ISSUES

Many organisations value their reputation above almost anything else. It is what they trade on, it is their image in the marketplace and possibly the most valuable (yet most easily lost) asset an organisation can have. With the current focus on environmental issues, any organisation seen or believed to be causing damage to the environment is likely to lose favour with significant sections of the market, including potential investors. If the environmental incident takes place at a critical time for the organisation, such as when negotiating finance for expansion or a major contract to supply a new customer, adverse publicity caused by the incident may result in the finance or the contract being withdrawn and, together with the civil and criminal sanctions imposed, may potentially lead to the downfall of the organisation.

## REVISION QUESTION

1. Briefly explain three reasons why organisations should have emergency plans in place.

(Suggested Answer is at the end.)

## KEY INFORMATION

- Some organisations, such as large chemical works, are required to produce an emergency plan, which addresses environmental issues. These organisations are controlled under national laws made to comply with **Directive 12/18/EU** on the control of major accident hazards involving dangerous substances (known as the **COMAH Directive**).
- Other organisations may produce emergency plans in response to Environmental Management System requirements, planning law, or because it represents good practice.
- Emergency plans should consider: possible accident scenarios, the predicted environmental effects, the implementation of specific control and mitigation measures, liaison with external bodies and the public, and measures for clean-up and restoration.
- Training and drills are important to ensure everyone is familiar with the emergency plan and it is implemented promptly and effectively.

If emergencies are to be dealt with effectively and efficiently, they must, as far as possible, be planned for in advance. Here we look at some of the elements that need to be prepared so that such planning is effective.

### EMERGENCY RESPONSE PLAN

Organisations of all types and sizes need to have an emergency plan in place. The key point is that the emergency plan should be appropriate to the scale and nature of the organisation's activities. A major facility, such as an oil refinery, will clearly have a much more extensive and detailed emergency plan than an office-based service organisation. In fact, larger industrial organisations that store chemicals above certain threshold limits (e.g. greater than 50,000 litres of fuel) are required, under **EU Directive 12/18/EU** on the control of major accident hazards involving dangerous substances (known as the **COMAH Directive**), to have an emergency plan in place that meets specified criteria.

Whatever the size and nature of the organisation, planning for environmental emergencies should follow similar principles used for fire and other health and safety emergencies. An emergency plan should contain the following elements:

- A central location should be identified where the details of the emergency plan are held and where incidents will be managed from. Large and complex organisations may have a dedicated Emergency Control centre or room.
- A designated person needs to take charge of any incident. Other roles and responsibilities need to be assigned, as appropriate, to maintain the emergency plan and to provide support during any incident.
- Site plans, including the location of drains and emergency equipment and materials, should be held centrally. The location of any sensitive neighbours, such as schools or hospitals, should be shown on the plan together with any sensitive environmental receptors (e.g. local river) that are close to the site.
- An inventory of hazardous materials (including type, quantity and safety data sheets) and their locations should also be held centrally.
- Telephone numbers for gas, water and electricity suppliers and the environmental regulator (e.g. the local office of the Environment Agency in England and Wales) should be held centrally.
- Details of any emergency warning systems, such as detectors and alarms, should be held centrally.
- Methods for advising local residents, businesses and any other parties likely to be affected by an incident should be in place.
- Procedures for dealing with specific accident scenarios (such as a major spill of a particular material held at a particular location) should be readily available.
- Training needs should be assessed and appropriate training given.

When developing an emergency plan to protect the environment, a number of issues should be considered:

- Potential accident scenarios should be identified and prioritised, taking account of the likelihood of the incident happening and the possible environmental consequences if were to happen, such as the:
  - Nature of the pollutant (solid, liquid, gas).
  - Toxicity and behaviour of any contaminant that might be released into the environment. Some apparently harmless substances can have a very damaging effect on the environment, e.g. milk can severely affect aquatic organisms if released into a watercourse, because of its high oxygen demand.
  - Persistence of any material that reaches the environment – a material that degrades very rapidly will have less impact than a persistent and toxic chemical.
  - Possible pathways by which any contaminant material might reach a sensitive receptor outside the boundary of the site (source-pathway-receptor) should be identified. A number of pathways might exist, e.g. via surface run-off into sewers, or via surface water drains leading to watercourses. The possibility that contaminants could be transported quite rapidly a long way from the immediate area should be considered. There may also be the possibility of contaminants reaching groundwater, e.g. if a spill occurs on un-made ground.
- Detailed procedures for dealing with high-priority accident scenarios should be developed and appropriate training given.

## TOPIC FOCUS

### COMAH

**EU Directive 12/18/EU** on the control of major accident hazards involving dangerous substances is generally referred to as the **COMAH Directive**. It is implemented in the UK by the **Control of Major Accident Hazards Regulations 2015**.

The **COMAH Directive** was introduced in the wake of the Seveso disaster. This emergency occurred in 1976 at a chemical plant located close to the Italian town of the same name. A process failure at the plant led to the release into the atmosphere of quantities of a highly toxic dioxin compound. Several hundred people in the surrounding area suffered skin lesions and over 80,000 farm animals had to be slaughtered to prevent dioxin entering the food chain.

The aim of the Directive is to reduce the risk of similar accidents occurring at installations that handle significant quantities of hazardous substances:

- The **COMAH Directive and Regulations** define upper and lower threshold quantities for a specified range of hazardous chemicals.
- Any site that stores any of the specified chemicals in quantities greater than either of the threshold quantities, must register with the Competent Authority (the Health and Safety Executive (HSE) and Environment Agency in England and Wales; the HSE and Scottish Environment Protection Agency in Scotland).
- If only the lower threshold quantity is exceeded, the site is designated as a 'lower-tier' site; any site which exceeds the higher threshold becomes an 'upper-tier' site.

Designated sites must take a range of actions to prevent accidents and limit their consequences, such as:

- Provide basic site details to the Competent Authority.
- Prepare a major accident prevention policy.

Upper-tier sites must also:

- Produce a regular site-safety report.
- Prepare and test an on-site (internal) emergency plan.
- Supply information to the local authority to enable an off-site (external) emergency plan to be prepared.
- Provide information to local residents about the substances held and emergency arrangements.

Whatever format the plan takes, it is essential that the contents of the plan are communicated to all those who will be involved in dealing with an emergency.

When considering an emergency plan to protect the environment, a number of issues should be considered:

- Possible accident scenarios.
- The predicted environmental effects of accidents.
- The implementation of specific measures to protect the environment.
- Liaison with other environmental organisations and the public.
- Environmental clean-up and restoration.

## EMERGENCY CONTROL CENTRE (ECC)

Larger sites usually have a separate, dedicated on-site building called the Emergency Control Centre. It should be located sufficiently far away from foreseeable sources of major incidents so that it remains operational throughout. The ECC acts as the nerve centre for operational management by the main controller during an on-site emergency. It is a prime consideration in the emergency plan. The ECC would typically be stocked with:

- On-site and off-site communication equipment (telephones, two-way radio, fax).
- Site plans/maps (marked with locations of site hazards, safety equipment, drainage routes, firewater supplies, fire-fighting equipment, local features, etc.).
- Contact details (including those for emergency response personnel, head office, hospitals, regulators, emergency services, media – though dealing with the media may be delegated to off-site personnel).
- Facilities to record the development of the emergency (such as whiteboards, plans and maps).

- Facilities to access data on those present at the facility at the time of the incident (i.e. roll-call).

It will probably not be feasible, or appropriate, for smaller organisations to have a dedicated ECC. Nevertheless, every organisation should have a central point for holding key information about the emergency plan and from where incident responses can be co-ordinated. This might be the gatehouse, or a senior manager's office. The location should be protected, as far as possible, from the effects of any likely accident, e.g. by being close to the site perimeter.

## TRAINING AND PRACTICES

Emergencies happen when we least expect them and, during an emergency, situations can change very quickly. For these reasons:

- It is essential that any employees or contractors who may be involved in dealing with an emergency situation are fully trained in their roles and responsibilities.
- Training may involve local emergency services, such as the fire service, ambulance or police. This will help to ensure that, should they be required during an emergency, they will have a good idea of the layout of any buildings as well as any potential hazards on site.

Testing should be based on an accident scenario identified as being reasonably foreseeable. Tests should address the response during the initial emergency phase, which is usually the first few hours after the accident occurs. This is the phase of an accident response when key decisions, which will greatly affect the success of any mitigation measures, must be made under considerable pressure and within a short period of time. This is, therefore, where a detailed understanding of the likely sequence of events and appropriate countermeasures is of great benefit.

The objective of testing the emergency plan should be to give confidence in the following constituents of the plan; these are the:

- Completeness, consistency and accuracy of the emergency plan and other documentation used by organisations responding to an emergency.
- Adequacy of the equipment and facilities, and their operability, especially under emergency conditions.
- Competence of staff to carry out the duties identified for them in the plan, and their use of the equipment and facilities.

The training does not always need to take the form of an exercise where potential accident situations are simulated, although carrying out these simulation exercises on a regular basis can:

- Be a great help in identifying problems and solutions.
- Give the participants an indication of how they will behave during an incident.

Other training methods can be used, such as tabletop exercises. These allow information exchange and dissemination between the organisations that may be involved in an incident, as well as decision-making, to be tested. They can be carried out in relation to a model, plans or photographs to depict the establishment.

## RECOGNISING RISK SITUATIONS AND ACTION TO TAKE

It is important that as part of the training of employees they become familiar with what is an emergency and what action to take. Not all spillages will be emergencies, although they will all likely need to be dealt with and cleaned up:

- A small spill of oil in a bunded area is unlikely to be classed as an emergency, but a spill of oil in an uncontained area with the potential to pollute a river needs to be treated as an emergency and dealt with immediately.
- A spill of diesel in an area that can be closed off to traffic need not necessarily be an emergency, but if it were petrol instead of diesel, on a hot day with possible ignition sources nearby, the situation would be very different.

Any unplanned fire should be treated as an emergency, as there is great potential for fire to spread quickly, causing great damage and cutting off potential evacuation routes. However, if the fire is within the waste of a landfill site, it is unlikely the fire service will be called, unless there is a risk of the fire spreading beyond the waste area to buildings. This is because landfill site staff will be trained to deal with this situation, and will have equipment that can reach the point of the fire, whereas it is unlikely that the fire service will be able to get their equipment across the rough ground of most landfill sites.

Ensuring employees respond at the correct level of urgency will help to make sure that incidents are dealt with effectively, and also prevent the development of a culture where any minor spill is treated as a major emergency. If this happens, the danger is that when a major emergency does occur, people feel it is just another case of overreacting, possibly leading to an inappropriate response.

## MATERIALS TO DEAL WITH SPILLS

It is important that the correct equipment is available to deal with the spillages that are likely to take place. Suitable spill kits need to be located at key locations around the site. This will include locations near to:

- Where chemicals are stored.
- Any drainage points that may act as pathways for the pollutant.

It is essential that the spill kits contain the correct materials for the possible pollutants and that people are trained in their use.

Colour-coding is used to identify the type of pollutant that the material can deal with. For example, some pads soak up oil but leave water behind, so it is important that the correct pads are used.

### TOPIC FOCUS

**Common equipment contained in a spill kit might include:**

- Mats for soaking up spills.
- Socks or booms for containment.
- Drain covers to seal drains and prevent pollution entering the drainage system.
- Granules for soaking up oils.
- Gloves and other relevant PPE.
- Wipes.
- Bags to put contaminated materials in.

It is important that spill kits are stored in suitable containers, especially if the kits are to be stored outside.

## ACCESS TO SITE PLANS

In order for the emergency plan to be effective, information about the site needs to be compiled and shown on a drawing easily available in the event of an emergency. Information should include:

- The layout of the site drainage system showing clearly the difference between drains going to foul sewer and those going to surface water.
- Assembly points for staff and visitors.
- Access routes and assembly points for emergency services.
- The location of any fire hydrants or high-pressure water points.
- The location of any flammable or explosive chemicals stored on site and any other locations that may prove dangerous to emergency service personnel.

It may be necessary to keep a number of copies of all these plans to ensure that at least one will always be available. It may also be advisable to locate a copy of the drawing in a cabinet at the main entrance to the site and/or the Emergency Control Centre; this will help to ensure that, should an incident occur when the site is unoccupied, emergency services still have access to the information before members of staff that may be on call are able to arrive at the site.

## INVENTORY OF MATERIALS

A key piece of information required in planning for any major emergency is the quantities of dangerous substances held (or likely to be held) on site at the time of the incident. In combination with knowledge of the nature of the material, this enables an estimate of the likely:

- scale,
- extent, and
- severity

of any incident. This information is needed for the:

- Development of on-site emergency plans.
- Emergency services so that they can plan for and mount an effective off-site response.


Quantities of dangerous substances on site will need to be known

## ENVIRONMENTAL HAZARDS ASSOCIATED WITH FIRE

The environmental hazards associated with fire will, to a large extent, depend on what is actually on fire. However, there are some hazards common to almost all fires:

- **Air pollution** – from any accidental fire there will always be smoke; the size of the fire and the properties of the burning material will determine how serious any air pollution is and how far that pollution will spread. Air pollution will also be impacted by weather conditions that may reduce or increase the severity of the pollution. Care should be taken during the preparation of the emergency plan to identify any potential receptors that may be particularly susceptible to the type of air pollution that would be caused by an accidental fire from your organisation. Potential receptors may be:
  - Natural environments easily damaged by poor air quality.
  - Human environments, such as care homes or hospitals.

  Suitable advice for these receptors can be prepared in advance, and consideration given to including the management of these facilities in some of the training and practice drills undertaken.
- **Water pollution** – surface water is easily polluted by both firewater run-off, and spills of oil or chemicals that occur as a result of the fire. It is essential that:
  - Sensitive water receptors are identified and noted in the emergency plan.
  - Procedures are in place to ensure potentially damaging substances are prevented from reaching these receptors.

  In some cases, this may require holding tanks or other specific areas to store the run-off water so that it can be treated before being discharged to the watercourse.
- **Land pollution** – land may become contaminated in exactly the same way as water does (see above). In some cases, this may not be important if the land is already put to an industrial or commercial use. However, if the land is used for agriculture or, for example, it is a Site of Special Scientific Interest (SSSI) then it must be protected. It is also important to understand what lies underneath the land as this may provide a pathway for future pollution of groundwater.

## LIAISON WITH REGULATORY BODIES AND EMERGENCY SERVICES

It is good practice, even for smaller organisations, to discuss potential emergency situations with the emergency services and the environmental regulator, to identify the best response approaches. Should an incident occur, the emergency services will also then have some prior knowledge of the layout of the site and the conditions they are likely to encounter.

The **COMAH Directive** sets out requirements for communicating and liaising with regulating bodies and emergency services. It also requires competent authorities to develop their own plans for dealing with a major incident. For those organisations not covered by national laws made to comply with the **COMAH Directive**, it is still good practice to discuss potential emergency situations with the relevant enforcement and emergency services to establish the best ways to resolve them.

If an emergency has occurred where there is any potential for a pollution incident to occur, e.g. chemicals have been spilt that might reach a local watercourse, there is a responsibility on the organisation to inform the regulator as soon as possible.

In some parts of the world, fire and rescue services have the ability to store and access plans and specific information while on route to an incident. Regular communication with the local fire and rescue service will ensure they have accurate, up-to-date information that they can rely on upon arrival at the scene. This helps to ensure that they can react quickly and safely to deal with the incident and that any specialist equipment required can be called out as early as possible.

## PROTECTING AND LIAISING WITH LOCAL RESIDENTS

Local residents (including any indigenous peoples) need to be kept informed about any incidents that might affect them. The emergency services may play an important role in this process, especially if any evacuation is required. The management of these communications should be included in the emergency plan. If people are not kept properly informed, then an accident could severely affect their health and safety and spread panic. Important methods of communication jammed by excessive use from neighbours and members of the public seeking information about the incident, hindering the effectiveness of the emergency response.

## HANDLING THE PRESS AND OTHER MEDIA

Dealing with the press and other media is often an issue that is not given full consideration until an emergency incident takes place and it then becomes clear that there is significant interest from local and possibly national media organisations. The reputation of an organisation is arguably one of its most important assets and one that is easily lost or damaged through poor communication to the public via the media.

In the absence of any accurate, open and honest information coming from the organisation, it is potentially inaccurate information that is publicised. Once that information is in the public domain, the organisation is in the position of having to deny or correct the information.

During the planning process for emergencies, it is important that:

- Specific people are identified as being those who will communicate with the media during an emergency.
- All other employees are given clear instruction not to talk to reporters and to direct any enquiries to those members of staff who have been allocated this role.
- Nominated staff members are properly trained in how best to communicate with the media.
- When an emergency occurs, there are systems and procedures in place to ensure that nominated staff are kept fully informed of the situation regarding the emergency.

Building good relationships with local press, radio and television reporters can be very beneficial, should an emergency incident occur, as they will automatically approach the member of staff they normally deal with, who is likely to be someone trained and experienced in dealing with the media. Local media can also be supportive in getting important mitigation information to the local population, such as the need to stay indoors and close all windows. This information will be more effectively distributed if the different parties involved are used to dealing with each other.

## REVISION QUESTIONS

1. Which sites are subject to the requirements of the **Control of Major Accident Hazards Involving Dangerous Substances Directive** (the **'COMAH' Directive 12/18/EU)?**
2. What is the main objective of testing an emergency plan?
3. List three pieces of information about the site that should be included in an emergency plan.
4. List the three main environmental hazards associated with fires.

(Suggested Answers are at the end.)

## SUMMARY

This element has dealt with environmental emergencies and how to plan for and deal with them.

In particular, this element has:

- Demonstrated that as part of their general duty or responsibility not to pollute, all organisations should have emergency plans in place, with the size and complexity of the plan depending on the nature of the organisation.
- Shown that emergency plans are necessary:
  - As part of the EMS – potential impacts under emergency conditions.
  - To ensure prompt action to protect people and mitigate potential consequences to the environment.
  - To pre-empt the possibility of prosecution and costs relating to fines, clean-up work and compensation.
  - To avoid adverse publicity in the event of an incident occurring.
- Described how the **COMAH Directive** aims to reduce the risk of accidents involving dangerous substances.
- Explained that on large sites the Emergency Control Centre acts as the nerve centre for operational management during an on-site emergency and should contain communication equipment, site plans, contact details, information recording facilities, etc.
- Shown that training in emergency procedures, including the use of simulation exercises, should be given to all employees/contractors. Training in the recognition of significant/less significant incidents should be included.
- Explained that there should be appropriate spill kits, stored in suitable containers, and that full site plans should be available as well as an accurate inventory of any dangerous substances on site.
- Outlined the environmental hazards associated with fire, including:
  - Air pollution: from smoke.
  - Water pollution: from firewater run-off; spills of oil or chemicals.
  - Land pollution: as per water pollution.
- Explained that regular communication with regulatory bodies and the emergency services will help to ensure efficient and speedy action when required by the occurrence of an emergency incident. The establishment of good relationships with the local media may prove to be beneficial to the public image of the organisation in the event of an incident occurring.


## QUESTION 1

**Outline** the actions required to ensure that emergency plans work effectively when needed. (8)

## QUESTION 2

**Outline** the contents of an environmental emergency plan. (8)

### APPROACHING QUESTION 1

Remember:

- Read the question.
- Consider the marks and time available.
- Highlight the key words.
- Read the question again.
- Write a plan.

Hint: this question is not asking for the content of an emergency plan.

### SUGGESTED ANSWER

**Plan**

Training, practices/drills, past incident analysis, review of plan, maintenance of systems/alarms, copies held at relevant locations, Emergency Control Centre equipment, audit of plan.

**Answer**

A key element for the effective operation of an emergency plan is that key staff are trained as to its contents. This should include both training for new staff and refresher training for existing staff.

The organisation should also undertake practices and drills – this may involve neighbours and external responders to the incident, such as the fire authority if appropriate.

If incidents do occur, they need to be closely analysed. If weaknesses in the plan are identified then the plan may need to be altered to ensure such shortcomings do not reoccur.

The plan should also be reviewed on a frequent basis and as the situation changes. The plan should reflect the actual emergency incidents which are likely to occur at the site.

Any systems and alarms should be regularly maintained to ensure that they are working correctly. Equipment that should be subject to regular maintenance includes emergency signage, visitor instructions and PPE.

Copies of the plan should be available at relevant locations. For example, a copy should be held in the Emergency Control Centre (ECC) which should be clearly identified as such. A copy of the emergency plan should also be held in an off-site location.

The ECC should also contain relevant equipment, such as communication devices, and contact details for relevant internal and external persons with regard to the plan.

The plan should also be audited on a regular basis (it may form part of a formal EMS such as those designed to **ISO 14001**). External audits by an environmental specialist will give a high level of confidence in the plan.

## APPROACHING QUESTION 2

Remember:

- Read the question.
- Consider the marks and time available.
- Highlight the key words.
- Read the question again.
- Write a plan.

## SUGGESTED ANSWER

**Plan**

Site plan, sensitive habitats and other receptors, drainage plan, list of operations, location of emergency equipment, firewater, warning system, responsibilities, contact details, review frequency (any eight).

**Answer**

Any eight from the following:

- A site plan should be included showing the location of the site in the context of its surroundings such as the location of nearby housing.
- The plan may identify the location of nearby watercourses and sensitive habitats that could be affected by an emergency at the site. This might include designated sites such as Sites of Special Scientific Interest (SSSIs).
- A drainage plan should be provided – this would identify the location and routes of different drains. This will allow those dealing with a potential emergency to be able to put extra controls in place to stop pollutants entering the drainage system.
- A list of operations on the site should be available such that those dealing with the emergency are aware of what raw materials and other potential polluting substances are present in an area, in addition to quantities.
- The location of emergency equipment should be provided. This might include spillage control equipment and fire-fighting equipment. This will ensure that the emergency can be dealt with quickly and effectively.
- A method of dealing with firewater should be provided within the plan. This might include the location and procedure for a sacrificial area (such as a car park) to contain the firewater.
- A warning system should be provided in the plan to ensure that people both on and off site are aware of the emergency and the actions that they should take to ensure that the risk of harm is minimised.
- The responsibilities of the Emergency Control Centre should be provided. This will include how it will operate during an emergency.
- Contact details of internal staff who play an important role in dealing with an emergency should be provided, in addition to those for external organisations such as the emergency services and regulatory bodies.
- The review frequency of the plan should be identified in addition to the person responsible for implementing the plan.

# REVISION AND EXAMINATION

## THE LAST HURDLE

Now that you have worked your way through the course material, this section will help you prepare for your NEBOSH examination. This guide contains useful advice on how to approach your revision and the exam itself.

# Unit EC1 Revision and Examination

## YOUR NEBOSH EXAMINATION

Your examination will consist of one exam paper which contains one 20-mark question and ten 8-mark questions. You are allowed two hours in which to complete the exam and you should answer all the questions.

To pass the EC1 exam, you must obtain a minimum of 45% of the total marks available. You will then be issued with a Unit Certificate for EC1, showing a pass grade.

Once you have been awarded a Unit Certificate for both Units (EC1 and EC2), you will receive an overall grade as follows:

| | |
|---|---|
| **Pass** | **105 to 124 marks** |
| **Credit** | **125 to 144 marks** |
| **Distinction** | **145 marks or more** |

The overall mark is calculated by adding together your two Unit Percentage scores.

If your performance in either Unit is less than the pass mark (which is 45% for EC1 and 60% for EC2 (the practical application)) then you will be "referred" in that Unit. If you are referred in one Unit you may resit that referred Unit provided you do so within **two years** of passing the other Unit. You may resit as many times as you want within that two-year timescale.

### Be Prepared

It may be some time since you last took an exam.

Remember, success in an exam depends mainly on:

- **Revision** – you have to be able to remember, recall and apply the information contained in your course material and
- **Exam technique** – you have to be able to understand the questions and write good answers in the time available.

Revision and exam technique are skills that can be learned. We will now look at both of these skills so that you can prepare yourself for the exam. There is a saying that "proper planning and preparation prevents a poor performance". This was never truer than in an exam.

## REVISION TIPS

### Using the Course Material

You should read through all of your course materials once before beginning your revision in earnest. This first read through should be done slowly and carefully.

Having completed this first revision reading of the course materials consider briefly reviewing all of it again to check that you understand all of the elements and the important principles that they contain. At this stage you are not trying to memorise information, but simply checking your understanding of the concepts.

Remember that understanding the information and being able to remember and recall it are two different things. As you read the course material you should **understand** it; in the exam you have to be able to **remember** and **recall** it. To do this successfully most people have to go back over the material repeatedly.

Re-read the course materials and make notes that summarise important information from each element. You could use index cards and create a portable, quick and easy revision aid.

Pay attention to the **Key Information** and **Topic Focus** boxes in this text, but do be aware that these only summarise some of the important points and focus on particular topics. They do not represent the only information that you need to remember.

Check your basic knowledge content of each element by reading the Summary. The Summary should help you recall the ideas contained in the text. If it does not, then you may need to revisit the appropriate sections of the element.

## Using the Syllabus Guide

We recommend that you purchase a copy of the NEBOSH Guide to this course, which contains the syllabus for your exam. If a topic is in the syllabus then it is possible that there will be an examination question on that topic.

Map your level of knowledge and recall against the syllabus guide. Look at the **Content** listed for each element in the syllabus guide. Ask yourself the following question:

*If there is a question in the exam about that topic, could I answer it?*

You can even score your current level of knowledge for each topic in each element of the syllabus guide and then use your scores as an indication of your personal strengths and weaknesses. For example, if you scored yourself 5 out of 5 for a topic in Element 1, then obviously you don't have much work to do on that subject as you approach the exam. But if you scored yourself 2 out of 5 for a topic in Element 3 then you have identified an area of weakness. Having identified your strengths and weaknesses in this way you can use this information to decide on the topic areas that you need to concentrate on as you revise for the exam.

You could also annotate or highlight sections of the text that you think are important.

Another way of using the syllabus guide is as an active revision aid:

- Pick a topic at random from any of the elements.
- Write down as many facts and ideas that you can recall that are relevant to that particular topic.

Go back to your course material and see what you missed, and fill in the missing areas.

## EXAM HINTS

Success in the exam depends on averaging half marks, or more for each question. Marks are awarded for setting down ideas that are relevant **to the question asked** and demonstrating that you understand what you are talking about. If you have studied your course material thoroughly then this should not be a problem.

One common mistake in answering questions is to go into too much detail on specific topics and fail to deal with the wider issues. If you only cover half the relevant issues, you can only achieve half the available marks. Try to give as wide an answer as you can, without stepping outside the subject matter of the question altogether. Make sure that you cover each issue in appropriate detail in order to demonstrate that you have the relevant knowledge. Giving relevant examples is a good way of doing this.

We mentioned earlier the value of using the syllabus to plan your revision. Another useful way of combining syllabus study with examination practice is to create your own exam questions by adding one of the words you might find at the beginning of an exam question (such as 'explain' or 'identify' or 'outline') in front of the syllabus topic areas. In this way, you can produce a whole range of questions similar to those used in the exam.

## BEFORE THE EXAM

You should:

- Know where the exam is to take place.
- Arrive in good time.
- Bring your examination entry voucher, which includes your candidate number, photographic proof of identity, pens, pencils, ruler, etc. (Remember, these must be in a clear plastic bag or wallet.)
- Bring water to drink and sweets to suck, if you want to.

## DURING THE EXAM

- Read through the whole exam paper before starting work, if that will help settle your nerves. Start with the question of your choice.
- Manage your time. The exam is two hours long. You should attempt to answer all 11 questions in the two hours. To do this, you might spend:
  - 25-30 minutes answering Question 1 (worth 20 marks), and then
  - 8-9 minutes on each of the ten remaining 8-mark questions.

  Check the clock regularly as you write your answers. You should always know exactly where you are, with regard to time.
- As you start each question read the question carefully. Pay particular attention to the wording of the question to make sure you understand what the examiner is looking for. Note the verbs (command words), such as 'describe', 'explain', 'identify', or 'outline' that are used in the question. These indicate the amount of depth and detail required in your answer. As a general guide:
  - 'Explain' and 'describe' mean give an understanding of/a detailed account of something.
  - 'Outline' means give the key features of something.
  - 'Identify' means give a reference to something (could be name or title).
- Pay close attention to the number of marks available for each question, or part of a question – this usually indicates how many key pieces of information the examiner expects to see in your answer.
- Give examples wherever possible, based either on your own personal experience, or things you have read about. An example can be used to illustrate an idea and demonstrate that you understand what you are saying.
- If you start to run out of time, write your answers in bullet-point or checklist style, rather than failing to answer a question at all.
- Keep your handwriting under control; if the examiner cannot read what you have written, then he or she cannot mark it.
- You will not be penalised for poor grammar or spelling, as long as your answers are clear and can be understood. However, you may lose marks if the examiner cannot make sense of the sentence that you have written.

# NEBOSH ENVIRONMENTAL CERTIFICATE

## UNIT EC2: ENVIRONMENTAL PRACTICAL APPLICATION

# UNIT EC2: ENVIRONMENTAL PRACTICAL APPLICATION

## INTRODUCTION

The aim of this unit is to help you prepare for your NEBOSH Environmental Certificate Unit EC2: Environmental Practical Application.

**Some people think that this unit is simple, don't bother to prepare themselves properly, and fail as a result. Make sure you don't fall into this trap!** While the process you have to move through is straightforward, in order to succeed you need to understand what NEBOSH expect. If you work carefully through these notes, we are confident that you'll be a successful candidate!

These notes are designed to give you guidance on completing your practical application, including:

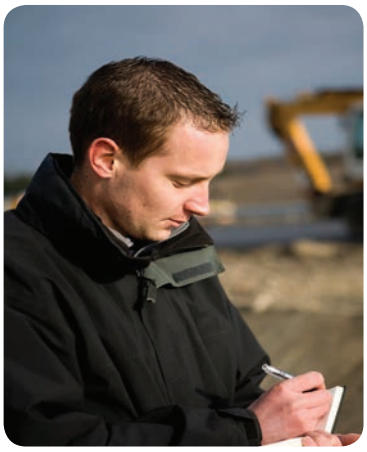
- how you should go about planning it;
- what it should include; and
- what needs to be submitted when.

The practical application is not something that should be left to the end of your studies. You should start thinking about it **now**.

# Contents

## AIM OF THE PRACTICAL APPLICATION

The aim of the practical application is to test your ability to carry out two activities:



**An environmental review of your workplace:**

- What are the actual and possible environmental issues?
- Are they adequately controlled?
- What, if any, remedial action is required?

**A written report to management:**

- Outlining what you found in your review.
- Explaining why action is needed (and persuading management to do it!).
- Identifying what they need to do to resolve the issues you have identified.

You have to write the report after you have carried out the environmental review, so allow yourself three hours to complete the whole assessment.

The following table outlines the key stages involved in completing the practical application, along with some useful tips about how to tackle each one.

| Stage | Key Tips |
|---|---|
| Choose the review area. | The area should be just the right size; not so large that it is over-whelming and not too small to provide enough information. |
| Complete the NEBOSH proforma (questionnaire). | Complete this as you walk around the practical area. Make sure you adequately justify your answers in the comments boxes. |
| Write the report. | Use the template (which you can find on the NEBOSH website) and follow the guidance below for each section of the template. |

Let's look at these stages in detail, starting with the environmental review.

## ENVIRONMENTAL REVIEW

For this assessment you have to show NEBOSH that you can competently complete an environmental review of a workplace, identifying any issues of concern and what needs to be done about them – and how quickly action should be taken. This gives you the opportunity to demonstrate your ability to apply the knowledge you have gained from studying the EC1 syllabus. You are expected to recognise actual and possible controlled and uncontrolled environmental issues as part of the review.

You will have already covered the types of environmental issues you are likely to come across in the workplace in Unit EC1 of your course, so we will not go into the detail of those here. Instead, we are going to concentrate on how you should approach the environmental review to give you the best chance of success.

### Choosing the Review Area

The environmental review on which your practical application will be based needs to be conducted at a place of work of your choice. Ideally, this will be your own place of work, but in making your selection NEBOSH recommend you bear the following points in mind:

- The chosen area must be:
  - Accessible to you.
  - Sufficiently simple and small to allow you to complete the practical application within approximately three hours. If the site you have chosen spans a large area, you should select a small section of this, such as a warehouse or single production depot. On smaller sites, you could cover the whole site in your review.
- Management must be willing to co-operate by providing information and giving their time.
- You should obtain prior agreement from senior management.
- The date of the review should be decided in advance and management given an indication of the information that will be required.
- There may be constraints affecting the practical application which you need to be aware of, such as issues of confidentiality. It may help to:
  - Reassure the manager responsible for your proposed review area that no names or other forms of reference to the company or location are required.
  - Mention that copies of findings could be made available for their use, although management must appreciate that this environmental review is for educational purposes only, and is not an assessment recognised for legislative or regulatory purposes.

    If any further confidentiality restrictions apply, you will need to contact your tutor immediately to see if appropriate measures can be agreed with NEBOSH.

    Any problems should be identified at the outset, and guidance sought from NEBOSH.

It is important that your practical application is able to fully integrate all the elements contained within the NEBOSH Certificate in Environmental Management syllabus.

### Completing the NEBOSH Proforma

As you carry out your environmental review, you need to complete the NEBOSH Candidate Environmental Review Proforma, which will provide you with notes to work from when it comes to completing your management report. **Remember that these notes will be submitted to your examiner, who will use them to decide how effective your management report is, so they must be clear and legible!**

The proforma is designed to cover the principal topics contained in the syllabus and to help you to structure your work.

#### HINT AND TIPS

You will find it useful to look through the proforma before deciding on the location for your practical application, as it will give you an idea of the sorts of things NEBOSH expect you to cover.

If there are any aspects of the proforma that you are unsure of, you should contact your tutor who will be happy to discuss it with you.

- The proforma consists of a series of questions which you should use to structure the review.
- The questions are designed to be answered by simple 'Yes', 'No' or 'Not applicable' responses.

Where a 'Yes', 'No' or 'Not applicable' does, or does not, apply, you should express the reason why in the Comments box. This is where you should list information to support an answer. Note that there is no requirement (nor marks available) for additional diagrams, plans, etc.

Remember that you should use the NEBOSH proforma as a guide – the practical application is assessed on your ability to apply theoretical knowledge.

## Undertaking the Environmental Review

Once you are happy with what the proforma expects of you, you should begin to make initial preparations for your practical application. This may involve anything from obtaining formal agreement from the managers responsible for the chosen area, to thinking about convenient dates when you could complete the review.

### HINT AND TIPS

You will find it useful to take a copy of the NEBOSH proforma so that you can complete it as you go through the review (leaving you with a clean copy to submit as your final version if you wish).

You should work your way systematically through the proforma. **Remember:** it has been designed to ensure that you cover all the principal areas of the syllabus and structure your report in the correct way.

Your completed proforma should clearly identify:

- The nature and location of each environmental issue.
- The degree of risk associated with the environmental issue.
- Preventive and protective environmental measures already in place.

Remember that:

- The questions in the proforma are designed to be answered by simple 'Yes', 'No' or 'Not applicable' responses.
- **You must always complete the comments boxes** below the questions to justify your answer.
- You may **handwrite or word-process** the proforma.

### HINT AND TIPS

It is important that you make full use of the comments boxes, as you need to describe what you have seen during the review and explain your reasoning for answering questions in the way you have. It will be impossible for you to write a sufficiently detailed report on the basis of 'Yes' or 'No' answers!

On the following pages you will find examples of completed questions from the proforma, showing the type of supporting information you might include in the comments boxes.

You will find a sample copy of the **actual proforma** on the NEBOSH Website.

Some of the sections (or individual questions in a section) may not apply to your chosen review area. This is not important, as it is your ability to apply theoretical knowledge in the practical application that will be marked, not the actual answers to the questions contained in the form.

If a question or section is not relevant, you should simply **write a note to indicate** this, explaining why it is not relevant. In the same way, you may come across additional points when completing your review which are not specifically mentioned on the proforma.

## USEFUL ADVICE FOR THE ENVIRONMENTAL REVIEW

**Do's**

- ✓ Do take a watch so you can manage your time effectively.
- ✓ Do take a clipboard.
- ✓ Do take the NEBOSH proforma.
- ✓ Do note down the finish time so you don't run out of time.
- ✓ Do have a general look around before you begin so you don't miss aspects.
- ✓ Do pace yourself.
- ✓ Do use all your senses.
- ✓ Do look for the simple stuff.
- ✓ Do look over, under, inside and behind objects and equipment.
- ✓ Do look in cupboards and stores.
- ✓ Do note down good controls in your comments boxes as well as bad.
- ✓ Do remember it's about quality, not quantity.
- ✓ Do write enough detail in each Comments box.
- ✓ Do look after yourself; workplaces can be dangerous environments for people who are unfamiliar with them.

**Don'ts**

- ✗ Don't waste time making trivial observations - they will not gain you any extra marks.
- ✗ Don't lose track of time – try to complete the assessment in three hours.
- ✗ Don't leave too many sections as 'Not Applicable'. If this is the case, you may have selected a workplace with inadequate environmental aspects.
- ✗ Don't worry if one or possibly two sections are not applicable – just justify why they are Not Applicable in the comments box.
- ✗ **Don't leave Comments boxes empty** – you may lose marks by doing this.
- ✗ Don't endanger yourself.

## REPORT TO MANAGEMENT

Hopefully you've now got a good understanding of what you need to do in the environmental review, but your work is not yet finished! Once you've completed the review, you need to write a report to management, based on your findings, that successfully persuades them to take appropriate action. To do this, you'll need to explain why such information is needed and identify the remedial measures that should be implemented.

The report should be concise and will be marked in terms of its value to management (not to the examiner)!

NEBOSH recommend that you include the following information:

- **Place and date of review.**
- **Introduction.**

  A description of the chosen area and the activities taking place to set a context for the practical application.

  – This might include: number of employees, location and size of the site, nearby sensitive areas, description of the activities, etc.
- **Executive Summary.**

  This should be a short summary of the whole report. A senior level manager should be able to read just the Executive Summary and gain a good idea of what you did, what you found, where good practice was noted, what the significant problems are and broadly what you recommend.
- **Main findings of the review.**

  This should be the longest section of the report.

  You should state what you found and clearly identify both the strengths and weaknesses of the management system. **This should be clearly based on the proforma** – there should be no new issues introduced at this stage. Include balanced arguments on why action is needed and explain the effect it would have on the standards of environmental control at the workplace and the possible effects on the business overall.
- **Conclusions.**

  Clear and concise conclusions which clearly relate to the review findings and are effective in convincing management to take action. **You should not mention any findings in this section that have not been stated in the main findings section**.

  This section should not be as long as the main findings section, but should be more than one sentence.

  – You might conclude that the site is generally well run (or not) and specify any key aspects that are inadequately controlled, giving consideration to legal requirements, liabilities and best practice.
- **Recommendations.**

  A plan which presents realistic recommendations to improve the environmental compliance and culture in the chosen area and includes estimated costs and priorities. Include appropriate resource implications, such as the amount of recommended training, if relevant.

  – Recommendations should be realistic and should relate to the weaknesses you identified in the Main Findings and Conclusions. Don't forget to include costs and priorities – exact costs don't need to be given, just a rough estimate.

### HINT AND TIPS

Remember that no additional information/ appendices should be included with your report, apart from your completed NEBOSH proforma.

On the next page you will find the sheet that will be completed by the assessor of your project. Read it carefully, as it will give you an indication of the marks that are allocated for each section of your project.

You need to bear in mind that when marking the practical application, NEBOSH will be mindful of the fact that you have had every opportunity to check every fact you put in the report. Therefore, while a little leniency may be granted with regard to the specific titles or years of legislation in the examination, NEBOSH will not grant such leniency with regard to the practical application. It is therefore vital that you check and double-check the accuracy of every element of your report, before you submit it.

Marks will not be deducted for poor spelling or grammar but you will lose marks if the examiner can't read or understand your completed report or proforma.

## FINAL REMINDERS

### Planning Your Practical Application

- ✓ Begin thinking about potential locations for your practical application immediately and talk to the managers of the proposed review site to obtain their co-operation.
- ✓ Study the course material until you are approximately halfway through Unit EC1.
- ✓ Contact your tutor to discuss your progress and ensure you are still on the right lines.
- ✓ **Complete your study of Unit EC1** before undertaking the review.

### Carrying Out the Review

- ✓ Conduct the environmental review and complete a rough copy of the proforma.
- ✓ Begin writing the report based on your observations from the proforma.
- ✓ Produce final copies of both the proforma and the report and submit by the day you sit your EC1 exam. Ensure that your NEBOSH candidate number is printed clearly at the top right-hand corner of each page.

**Note:** Remember that your tutors are there to help you do as well as you can. Don't be afraid to contact them if you have any problems with the practical application.

# SUGGESTED ANSWERS


## NO PEEKING!

Once you have worked your way through the revision questions in this book, use the suggested answers on the following pages to find out where you went wrong (and what you got right), and as a resource to improve your knowledge and question-answering technique.

# Unit EC1 Element 1: Foundations in Environmental Management

## Question 1

The three media that make up the 'environment' are air, water and land.

## Question 2

Much of the solar radiation that strikes the planet surface is reflected back towards space. Although carbon dioxide, water vapour, methane, chlorofluorocarbons (CFCs) and some other gases in the atmosphere are transparent to visible light, they intercept and absorb much of the reflected infrared radiation, re-reflecting it back towards Earth. This process retains some of the solar heat and is called the 'greenhouse effect'.

When greenhouse gases build up in the atmosphere, more heat is trapped near the Earth's surface. Ocean surface temperatures rise, so more water vapour enters the atmosphere and the Earth's surface temperature rises more. This is 'global warming'.

## Question 3

The three main reasons why organisations need to manage environmental impacts are:

- Ethical (or moral).
- Legal (or social).
- Financial (or economic).

## Question 4

Legal and economic effects that could occur following a pollution incident include:

- Cost of fines.
- Clean-up costs.
- Compensation payments.
- Indirect costs from loss of credibility and support in the market.

(Only three were required.)

## Question 5

Achieving sustainable development requires four objectives to be met:

- Effective protection of the environment.
- Prudent use of natural resources.
- Maintenance of stable levels of growth.
- Social progress.

These are often conflicting objectives. For example:

- 'Prudent use of natural resources' could involve no longer extracting fossil fuels. This would result in the loss of the most commonly used energy source in the developed world. Without dramatic technological advances, we would be unable to drive vehicles and manufacture products. In such an extreme example, the economy is likely to collapse and there would be social regression rather than progression.
- 'Social progress' of developing countries is likely to lead to more damage to the environment, but social progress is an objective of sustainable development.

## Question 6

(a) The Montreal Protocol on Substances that Deplete the Ozone Layer.
(b) The Ramsar Convention on Wetlands of International Importance.

## Question 7

BPEO (Best Practicable Environmental Option) is defined as "the outcome of a systematic consultative and decision-making procedure which emphasises the protection and conservation of the environment across land, air and water. The BPEO procedure establishes for a given set of objectives, the option that provides the most benefits or the least damage to the environment, as a whole, at acceptable cost, in the long term as well as in the short term".

## Question 8

Environmental permits are often required for:

- Discharge to groundwater.
- Keeping, treating and disposing of waste.
- Emissions of pollutants to air.
- Operations where more than one activity includes a permit (when an integrated permit is used).

# Unit EC1 Element 2: Environmental Management Systems

## Question 1

Implementation of an EMS can involve substantial resources, such as time, money, facilities and people. Such resources are only likely to be available if management are committed to the project and allocate the resources.

If management are known and seen to be committed to the project, other people are more likely to take time out from their other priorities and objectives to provide information and assistance critical to the implementation of the EMS.

If management support the project as being a priority, all staff will treat it as a priority.

Management are key to the dissemination of information and to training and educating the workforce. If they are committed to the project, they will help all in the organisation to understand the concept and importance of environmental management.

## Question 2

An environmental policy is a public declaration by the senior management of an organisation of their commitment to protecting the environment. It should set out the organisation's intentions regarding the environment and is the foundation upon which an Environmental Management System (EMS) can be built.

It must reflect the reality of the activities that the organisation undertakes and it must be a catalyst for action by the organisation. An effective and active policy provides an environmental framework within which all decisions can be made.

## Question 3

The seven key stages within an **ISO 14001** Management System are:

- Context of the organisation.
- Leadership.
- Planning.
- Support
- Operation.
- Performance evaluation.
- Improvement.

## Question 4

Responsibility for preparing and endorsing a written environmental policy rests with the organisation's senior director or senior manager, who is also responsible for ensuring that it is implemented, reviewed at appropriate intervals and updated when necessary.

## Question 5

The following are the main inputs to the management review:

- Results of internal audits and evaluations of compliance with legal and other requirements.
- Communication from interested external parties, including complaints.
- The environmental performance of the organisation.
- The extent to which objectives and targets have been met.
- The status of preventive and corrective actions.
- Follow-up actions from previous management reviews.
- Changing circumstances, including developments in legal and other requirements.
- Recommendations for improvement.

(Only three were required.)

## Question 6

The frequency of the inspections will be dependent on issues such as:

- The purpose of the inspection.
- Any frequency imposed by regulations, such as discharge consent and environmental permits.
- The level of risk to the environment.
- Conditions found at the last inspection.

## Question 7

The minimum requirements for someone carrying out an environmental inspection are as follows:

- An understanding of the tools of workplace inspections, their advantages and disadvantages and how to use them.
- An understanding of the process or activity being inspected.
- Knowledge of the potential environmental impacts from the process or activity.
- Knowledge of the standards that are acceptable.
- A basic report-writing ability or ability to use a checklist.

## Question 8

Audits are a pre-planned, systematic and objective assessment of a situation against a given set of criteria. For example, consider the following as a criterion: Clause 4.2 of **ISO 14001:2004** states that "top management shall define the organisation's environmental policy and ensure that, within the defined scope of its environmental management system, it is appropriate to the nature, scale and environmental impacts of its activities, products and services". Thus, against this particular point, the auditor would be looking for evidence to establish that a policy is in place, has been agreed by top management and is appropriate to the nature and scale of the organisation.

Inspections are an assessment of what is there at the time an inspection takes place. They are essentially looking for signs of failure, e.g. leaks in pipes, broken lights, signs of damage, etc.

## Question 9

You could have chosen any of the following benefits and limitations associated with the implementation of an EMS and certification to the 14001 standard:

**Benefits**

- Increased compliance with legislative requirements.
- Competitive edge over non-certified businesses.
- Improved management of environmental risk.
- Increased credibility that comes from independent assessment.
- Savings from reduced non-compliance with environmental regulations.
- Heightened employee, shareholder and supply chain satisfaction and morale.
- Meeting modern environmental ethics.
- Streamlining and reducing environmental assessments and audits.
- Increased resource productivity.

**Limitations**

- Prescriptive environmental performance levels are not included within the standard.
- Improvements in environmental performance can be negligible.
- Lack of public reporting, unlike other internationally recognised management systems.
- Inconsistency of ISO auditors.
- Implementing an EMS may have high cost implications for small- and medium-sized enterprises.

(Only three benefits and three limitations were required.)

## Question 1

'Environmental aspect' can be defined as an "element of an organisation's activities or products or services that can interact with the environment".

'Environmental impact' can be defined as "any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's environmental aspects".

## Question 2

Life-Cycle Analysis (LCA) is a tool to identify and measure the environmental impact of a product or service throughout its life cycle, from cradle to grave. This information can then be used to inform the decision-making process regarding new products, or to make changes to materials used in existing products.

The **ISO 14040** series provides guidance on aspects of LCA.

This cradle-to-grave approach helps to identify the total impact a product has on the environment.

## Question 3

Direct impacts:

- Air emissions from running vehicle engines in the workshop.
- Air emissions from a waste oil burner used to provide heat to the workshop.
- Accidental spillage of oil into the public sewer at the garage.
- Contamination of the land through spillages of oil and fuel in the workshop.

Indirect impacts:

- Methane gas generated from a landfill site that disposes of the garage waste (the direct impact is caused by the company operating the landfill).
- Use of electricity from the energy provider to heat offices (the direct impact is caused by the producer of the electricity, e.g. a nuclear power plant).
- Purchasing of office desks, made from non-renewable hardwoods (the direct impacts are from emissions caused by the manufacturer of the furniture and the loss of natural resources caused by the timber company).
- Water discharges caused in the manufacture of engine parts (the direct impact is caused by the emissions from the manufacturer of the engine parts).

## Question 4

| Internal Sources | External Sources |
|---|---|
| Inspection/audit reports | Manufacturers' data |
| Incident data and investigation reports | Legislation |
| Maintenance records | Enforcement bodies guidance documents |
| Job/task analysis | Government-supported organisations |
| Monitoring results | Trade associations and professional institutions |
| Raw material usage and supply | International/British Standards |
| Permits and consents | Commercial organisations/ Encyclopaedias/Textbooks |

(Only three of each were required.)

## Question 5

The following criteria might be used in deciding whether an environmental impact is significant or not:

- Scale and severity and probability/likelihood of occurrence – estimates of severity and likelihood are typically assigned qualitatively or semi-quantitatively (e.g. a scoring system) and an overall 'risk rating' determined.
- Legal or contractual requirements – if there is legislation that applies to an environmental aspect then the impacts must be defined as significant.
- Insufficient data or information – where there is insufficient information to accurately identify the severity of an impact then it would be wise to adopt the precautionary principle and identify that impact as significant until more information is available.
- Costs of raw materials or energy – if these are relatively high then the impact on the business is likely to be significant, therefore the impact should be considered significant.
- The concern of interested parties (views of local communities and other stakeholders) and the effect on public image – environmental issues are likely to attract significant attention and so should be well managed and controlled.

- Sensitivity of receiving environment – if there are known sensitive habitats nearby that may be adversely affected by an activity, then the impacts from that activity should be rated as significant and managed accordingly.
- Frequency (intermittent or continuous impact) – if an impact is likely to be continuous then it is more likely that it should be considered significant.
- Duration of impact (temporary or permanent) – if an impact is likely to result in permanent changes to the environment then it should usually be considered significant.

(Only three were required.)

## Question 1

The short-term effects of human exposure to air pollution include irritation and inflammation of the airways, eyes and mouth.

## Question 2

Vapours are the gaseous state of materials which are liquid at normal temperature and pressure.

Mists are fine liquid droplets, usually nucleated by a particle.

Fumes refer to very small particles of less than one micron that are suspended in flue gases and air.

## Question 3

The three options that make up the control hierarchy are as follows:

| Control Hierarchy | Example |
|---|---|
| Eliminate | Replace solvent-based chemicals with water-based chemicals. This has been done very effectively in the paint and ink industries where solvent-based products are now much less common than they used to be. |
| Minimise | This has been achieved in the motor industry through the use of improved technology, such as engine management systems and fuel injection. |
| Render Harmless | Fabric filters removing dust from a gas stream by passing through a fabric. |

## Question 4

The principle of all wet scrubbers is that water droplets are generated within the device and particles are captured within the droplets. The droplets are then removed from the air stream which is now clean. The droplets are collected as contaminated water, and transported out of the device for treatment or disposal. Wet scrubbing is used to control sticky emissions which may block filter-type collectors, to handle waste gas streams containing both particulates and gases, to recover soluble dusts and powders and to remove metallic dusts, such as aluminium, which may explode if handled dry.

Wet scrubbing techniques are normally used where the:

- Contaminant cannot be removed easily in a dry form.
- Waste gas stream contains both particulates and soluble gases.
- Particulates to be removed are soluble or wettable; they would adhere to the inner surfaces of a cyclone or bag filter plant and clog it.
- Contaminant will undergo some subsequent wet process, such as sedimentation, wet separation or neutralisation.
- Pollution control system must be compact.
- Particulates may ignite or explode if collected in a dry form.

## Question 5

The main objective of LEV is to extract the flow of air away from a work process using hazardous airborne substances. The air is cleaned, often with a bag filter, before exhausting it to the outside atmosphere.

# Unit EC1 Element 5: Control of Contamination of Water Sources

## Question 1

We rely on abstracting water from many different water bodies, such as rivers and from underground, for drinking, agriculture and commercial use. Many species of wildlife rely on good quality water in rivers, streams and lakes to survive and breed. Clean water is critical to both humans and wildlife. The water cycle shows us that water is continuously moved around, in one form or another. Pollution can also be transported with the water in the same cycle. For example, a polluting discharge going into a river is likely to reach a lake. Spillage of a chemical into a lake will ultimately pollute groundwater and soil. Pollution and its harmful effects can therefore become widespread, whichever of the water bodies is polluted. All waters must therefore be protected.

## Question 2

The two main categories of water pollution sources are:

- Point sources – distinct sources, such as pipelines, ditches, etc. and relatively easy to identify and control.
- Non-point or diffuse sources – including run-off from fields of fertilisers and pesticides and acid rain. They are more difficult to identify than point sources and therefore harder to control.

## Question 3

The main sources of water pollution include:

- Surface water drainage – collects rainwater falling on a variety of surfaces and will wash into the system any contaminants on the surface where rain has fallen. These will then be washed into the watercourse.
- Risks of contamination from spills – many industrial sites will have a combination of foul water drains and surface water drains. It is essential that these are identified, as any spills must be contained and the appropriate regulator informed if there is a risk that the pollution will enter either a controlled water or a sewerage system.
- Process and cooling water – water is often used as a coolant and so will also collect heat. Warm water retains much lower levels of oxygen than cold water and so volumes must be controlled in order to reduce any damage to the natural environment.
- Sewage – many sewage works have storm-water systems that allow the discharge of raw sewage to a river in the event of high rainfall. Other failures in the sewerage system, such as the blocking or breaking of sewer pipes, can lead to contamination.
- Solids – grit and plastics, etc. end up in rivers, lakes and on beaches. Grits and silts (e.g. cement) are washed from building activities into rivers.
- Contamination from natural minerals, e.g. arsenic, which has been identified in groundwater in Bangladesh.

(Only three were required.)

## Question 4

The main methods used to reduce contamination of water resources are:

- Screening.
- Solids separation and removal of organic load (coagulation).
- Centrifugal separation.
- Sedimentation/flotation.
- Filtration.
- Correction of pH.

(Only five were required.)

## Question 1

The **Waste Framework Directive (2008/98/EC)** describes waste from the point of view of the person discarding it as: "any substance or object which the producer or the person in possession of it discards, or intends or is required to discard".

## Question 2

Under the **Waste Framework Directive**, a waste is classified as 'hazardous' if it meets at least one of the following criteria:

- Explosive, flammable and oxidising substances.
- Irritants and corrosives.
- Biohazards (infectious, carcinogenic, mutagenic, teratogenic).
- Ecotoxics.
- Waste that releases toxic gases in contact with water, air or an acid.
- Sensitisers.

## Question 3

The five basic elements of the waste hierarchy are:

- Prevention – not making it in the first place.
- Preparing for re-use – e.g. by cleaning, repairing, etc.
- Recycling – (e.g. glass, metal, paper) requires some form of treatment. Composting involves bacterial processing of biodegradable waste.
- Other recovery – e.g. recovering heat when burning waste.
- Disposal – generally to landfill – least desirable option.

## Question 4

Waste could potentially escape from control in a number of ways, including:

- Corrosion or wear of containers.
- Accidental spills or leaks.
- Breach of containment by weather.
- Blowing away or falling from vehicles or storage.
- Scavenging by vandals, thieves, children, trespassers or animals.

(Only three were required.)

## Question 5

The following nuisances must be adequately controlled:

- **Noise nuisance**: heavy vehicle movements, both site traffic bringing waste for disposal and site plant. Licence conditions may specify working hours.
- **Odours**: minimised by the cell method of filling, ensuring the surface is covered with inert fill at the end of each working day, and operating to minimise exposed areas. Chemical sprays to mask smells may be used in unusual wind conditions.
- **Dust and litter**: minimised by damping down and good site practice, e.g. cell filling by tipping down a gradual slope and using specially designed plant to bury litter and increase the fill density, maximising the site capacity and minimising later settlement. This also reduces the possibility of fire (producing smoke, smells and contaminated leachate) starting in the waste.
- **Vermin**: gulls, rats, mice and foxes. Good site practice is required, and possibly an eradication programme for rats.

## Question 6

You could have chosen any of the following:

| | Advantages | Disadvantages |
|---|---|---|
| **Landfill** | • Comparatively cheap disposal.<br>• Can be used to restore areas used for quarries, etc. to local amenity use.<br>• Able to take large volumes of waste.<br>• Modern landfill is safe for humans and the environment.<br>• Can be used to generate electricity. | • Cheap, so does not encourage producers and consumers to migrate up the waste hierarchy.<br>• Waste does not break down quickly, so the problem of management remains for a considerable time after a site has closed.<br>• Poorly managed sites can lead to:<br>– Surface and groundwater pollution from leachate.<br>– Air pollution from unmanaged LFG or fires. |
| **Incineration** | • Reduction in volume.<br>• Allows heat to be recovered.<br>• An energy source. | • High initial cost.<br>• Volume of traffic.<br>• Monitoring of air pollution.<br>• Disincentive to recycling schemes (incinerators may need constant feeding). |

(Only three advantages and three disadvantages of each were required.)

## Question 7

Direct water contamination could occur by migration through plastic water pipes (especially of phenols and cresols) into household water supplies. Indirect water contamination could occur by leaching into groundwater.

## Question 8

The hazards associated with land contamination include:

- Ingestion.
- Food chain plant uptake.
- Contamination of drinking water.
- Prevention/inhibition of plant growth.
- Odours.
- Fumes.
- Fire and explosion.
- Direct contact.
- Building damage.

# Unit EC1 Element 7: Sources and Use of Energy and Energy Efficiency

## Question 1

Some of the advantages and disadvantages of the use of fossil fuels are:

| Advantages | Disadvantages |
|---|---|
| Straightforward combustion process. | Major contributor to climate change. |
| Relatively inexpensive. | Cause acid rain. |
| Easily transported. | Use a non-renewable source of energy so not sustainable in the long term. |
| Large amounts of electricity can be generated in one place, quite cheaply. | Prices are susceptible to changes in global politics so may rise significantly at short notice. |
| Gas-fired power stations relatively efficient. | Extracting raw materials can be dangerous and damaging to the environment. |
| Power stations can be built almost anywhere. | Emissions may contribute to poor air quality locally, thereby affecting people's health. |

(Only three advantages and three disadvantages were required.)

## Question 2

The three main ways in which we use solar power are:

- **Solar cells** (photovoltaic or photoelectric), where photovoltaic panels convert light into electricity at an atomic level through the use of materials that exhibit a property known as a photoelectric effect. This effect causes them to absorb photons of light and release electrons. When these electrons are captured, an electric current is generated.
- **Solar water heating**, where energy from the sun is used to directly heat water in glass panels, thereby reducing the amount of energy from fossil fuels required to provide hot water for use in the house.
- **Solar furnaces**, which are commercial installations that use a large number of mirrors to concentrate the energy of the sun into a small space and allow the production of very high temperatures. Some of these furnaces can produce temperatures up to 33,000°C.

## Question 3

Combined Heat and Power (CHP) is the generation of usable heat and power (usually electricity) in a single process.

CHP systems can be employed over a wide range of sizes, applications, fuels and technologies. In its simplest form, CHP employs a gas turbine, engine or steam turbine to drive an alternator and the resulting electricity can be used either wholly or partially on site with any excess being supplied to the national grid system. The heat produced during power generation is recovered, usually in a heat recovery boiler, and can be used to raise steam for a number of industrial processes, to provide hot water for space heating or, with appropriate equipment installed, cooling.

CHP is a form of decentralised energy technology. CHP systems are typically installed on site, supplying customers with heat and power directly at the point of use and therefore helping to avoid the significant losses which occur in transmitting electricity from a large centralised plant to the customer.

## Question 4

'Peak Load' and 'Peak Demand' are two terms that are used interchangeably to denote the maximum power requirement of a system at a given time, or the amount of power required to supply customers at times when need is greatest.

## Question 5

Energy efficiency initiatives may fail for the following reasons:

- Insufficient top-level support (visible and real commitment from senior managers).
- Funding (there may be a need to invest in new equipment or new controls for existing equipment).
- Inadequate resources (lack of suitable resources in terms of time and equipment).
- Lack of co-ordination across an organisation (different strategies being followed by different parts of an organisation, resulting in confusion about what staff are supposed to be doing).
- Lack of targeting (identifying where the biggest gains can be made first).

# Unit EC1 Element 8: Control of Environmental Noise

## Question 1

The following could all be sources of noise nuisance:

- Noise from commercial activities.
- Transport noise.
- Agricultural noise.
- Construction noise.
- Quarrying and mining.
- Noise from pubs and clubs.
- Neighbour noise.
- Intruder and vehicle alarms.
- Wind farms.

(Only five were required.)

## Question 2

Examples of management controls in relation to noise are:

- Control of working hours – usually to reasonable daytime hours.
- Controlling the use of radios (both music and two-way radios) – radios used for communication and entertainment can cause a nuisance to others nearby.
- Public address systems – should be designed so that sound is directed where it needs to be heard and not beyond the boundaries.
- Vehicle routes – proper routeing of vehicles, together with signage indicating any prohibited areas or routes, can reduce the nuisance caused.
- Loading doors and shutters – ensuring these are kept closed when not in use, especially during the night, can significantly reduce the noise levels and the potential for nuisance.

(Only three were required.)

# Unit EC1 Element 9: Planning For and Dealing with Environmental Emergencies

## Question 1

The following are some of the reasons why organisations should have emergency plans in place:

- General responsibility not to pollute the environment.
- As part of an Environmental Management System (EMS).
- To ensure prompt action to protect people and the environment.
- Risks of prosecution and other costs.
- Reputational issues.

(Only three were required.)

## Question 2

A site is subject to the requirements of the **COMAH Directive** if it stores any of the chemicals specified in the Directive in quantities that exceed the specified threshold levels.

## Question 3

The objective of testing the emergency plan should be to give confidence in the following constituents of the plan:

- The completeness, consistency and accuracy of the emergency plan and other documentation used by organisations responding to an emergency.
- The adequacy of the equipment and facilities, and their operability, especially under emergency conditions.
- The competence of staff to carry out the duties identified for them in the plan, and their use of the equipment and facilities.

## Question 4

Information should include:

- The layout of the site drainage system showing clearly the difference between drains going to foul sewer and those going to surface water.
- Assembly points for staff and visitors.
- Access routes and assembly points for emergency services.
- The location of any fire hydrants or high-pressure water points.
- The location of any flammable or explosive chemicals stored on site and any other locations that may prove dangerous to emergency service personnel.

(Only three were required.)

## Question 5

The three main hazards common to almost all fires are air pollution, water pollution and land pollution.