

M507 Module Syllabus

Health Effects of Hazardous Substances

Teaching Aims

This course aims to provide an introduction to the principles of toxicology, the main types of harmful effects to target organs from exposure to chemical hazards at work, and the hazards associated with common hazardous substances.

Prior Knowledge and Understanding

There are no prerequisites required for this qualification, however, candidates for this course are expected to be aware of the contents of the Control of Substances to Health (COSHH) regulations and The Chemicals (Hazard Information and Packaging for Supply) Regulations (CHIPs) especially with regard to labelling and safety data sheets.

This course is suitable for technicians and technologists who conduct measurements and testing in workplaces.

Learning Outcomes

On completion of this module, candidates will have a basic understanding of the following:

- **Provide definitions of commonly used toxicological terms**
- **Describe the main routes by which hazardous substances can enter the body, and the factors which influence their absorption, distribution, storage, and elimination**
- **Describe the main sources of information on hazardous substances and processes**
- **Describe the key features of the principal target organs affected by hazardous substances at work, and the factors which influence the degree of harm.**
- **Describe the main routes of exposure and toxic and health effects for hazardous substances commonly encountered in the workplace.**
- **Conduct basic interpretation of the results from epidemiological studies**

Content

The syllabus is structured into five sections:

		Time Allocation
1	Basic Principles of Toxicology	25%
2	Physiology and Target Organs	30%

3	Epidemiology	15%
4	Health Effects and Industrial Processes	30%
5	An Outline to Biological Agents	

(Please Note: an outline of Biological Agents is provided for reference purposes only. The candidates understanding of this section of the syllabus is not included in the final examination. The inclusion of this section is simply to provide candidates with awareness that consideration of exposures to Biological Agents would also be important in certain workplace situations.)

Note:

Reference is made in this syllabus to HSE guidance and other documentation. This list may not include the most up-to-date relevant publications from HSE and other sources and is intended as guidance for candidates only.

1 Basic Principles of Toxicology (25%)

This section will provide candidates with suitable knowledge and training to ensure that the candidate can demonstrate their understanding in the following:

1.0.1 Definitions:

Acute, Chronic, Local, Systemic, Allergic reaction, Sensitiser, Carcinogen, Mutagen, Teratogen, Xenobiotic, Stochastic, Non-Stochastic

1.0.2 Basic Pharmacokinetics:

- **Absorption:** Routes of absorption for substances, when ingestion can occur, situations where skin absorption and penetration can occur
- **Distribution:** main distribution pathways, blood, lymphatic system
- **Storage:** How chemical properties of a substance influence the site of storage and common examples of where materials are stored (e.g. solvents in fatty tissues, lead in bones, liver as a storage organ)
- **Biotransformation:** Meaning of biotransformation, where biotransformation occurs, how biotransformation can initiate or enhance toxic effects (examples - benzene, dichloromethane, methanol)
- **Elimination:** Definition of biological half-life, wide variation of half-lives, shape of curve

1.0.3 Dose Response Relationships:

- Meaning of dose response relationships
- Typical shape of dose response curve
- Concept of threshold and no-observed adverse effect level
- Dose response curves without threshold
- Importance of slope of curve

1.0.4 Toxicity Testing:

- Meaning of LD₅₀, LD_{Lo}, LC₅₀, LC_{Lo}, TD₅₀, TD_{Lo}, TC₅₀ and TD_{Lo}
- Units used to express results of animal testing
- Types of toxicity testing – toxicokinetic studies, acute toxicity studies, sensitisation studies, repeated dose toxicity studies, genotoxicity studies, reproductive and developmental toxicity studies, carcinogenicity studies
- Uses of toxicological data and estimation of safe human dose
- Limitations of toxicity testing data.

1.0.5 Types of Combined Effects:

- Addition
- synergism
- potentiation
- antagonism
- independent

1.0.6 General Health Effects:

- Asphyxia
- Irritation
- Narcosis
- Toxicity

1.0.7 Carcinogens:

- Basic mechanisms of Carcinogenicity (genotoxicity, Irritant etc.)
- Benign and malignant tumours
- Difficulties in identifying causal agents, long latency periods
- IARC classifications

1.0.8 Sensitisers:

- How sensitisation affects individuals
- Sensitisers (respiratory, animal allergy, skin - chromium)
- Uncertainty about thresholds
- Mechanisms of sensitisation and assessment methods

1.0.9 Reproductive Effects:

- Teratogens

2 Physiology and Target Organs (30%)

This section will provide candidates with suitable knowledge and training to ensure that the candidate can demonstrate their understanding in the following:

2.0.1 The main regions of the respiratory system:

- Head airways region: role of turbinate filtration mechanisms
- Tracheobronchial region: Structure, dimensions of air passages

- Mucociliary escalator
- Alveolar region: Surface area, Retention time of particles, Lack of cilia

2.0.2 Particles:

- Definition of aerodynamic diameter. Relevance of particle size
- Particle deposition and clearance
- Main deposition mechanisms; Interception, Impaction, Sedimentation, Diffusion
- Particle size ranges from each of the three regions
- Particles: Those deposited in the alveoli, fate of particles deposited elsewhere, including absorption via digestive tract
- ISO Curves: Inspirable, thoracic, and respirable curves, Shape of respirable curve

2.0.3 Gases and Vapours:

- Absorption through the lungs
- Gases; Importance of solubility

2.0.4 The Lung as a Target Organ:

- Gaseous contaminants: Acute irritancy, Role of solubility in determining region affected, Chronic effects
- Causes and consequences of inflammation.
- Benign pneumoconiosis: Definition, Main agents (iron, tin, barium)
- Fibrosis: Definition. (Crystalline Silica, Asbestos etc.)
- Emphysema (Cadmium Oxide etc.)
- Cancer (Rubber fume, Arsenic, Hexavalent Chromium etc.)

2.0.5 Allergic Conditions:

- Rhinitis - symptoms, nonspecific nature, wide range of agents
- Asthma - symptoms, common causes (isocyanates, solder fume, metals, latex, vegetable dusts, animal proteins, and enzymes (industrial and food utilisation))
- Allergic alveolitis - symptoms, causative agents for farmers lung and other moulds
- Byssinosis - symptoms, main stages of textile process associated with disease
- Assessment methods – Lung function testing, Challenge testing, Skin prick testing, Blood iGe analysis etc

2.0.6 Skin:

a) The structure and function of different layers and components:

- Stratum corneum and epidermis
- Dermis
- Hair follicles
- Sweat glands
- Nerves
- Fat

- b) Mechanisms of cutaneous protection against chemical penetration and biological agents:
- The skin as a target organ
 - Definitions, main mechanisms and common causes of irritant contact dermatitis, allergic contact dermatitis (nickel, epoxy resins), folliculitis, pigment disturbances, Ulceration, Cancer

2.0.7 Nervous System:

- a) Central and peripheral nervous systems:
- definitions, roles, structure of nerve cells, transmission of nerve impulses; transmission along cells, transmission across synaptic gap
 - Nervous system as a target organ
 - Role of volatile organic compounds as depressants
- b) Definitions, main mechanisms, and common causes of:
- Damage to nerve cells (lead, mercury, n-hexane, manganese.)
 - Deactivation of cholinesterase (organophosphates)

2.0.8 Circulatory system:

- Composition of blood and role of constituents
- Blood as a target organ

Definitions and common causes of:

- Haemolysis (arsine and stibine)
- Carboxyhaemoglobin formation (carbon monoxide - from direct exposure and from metabolization of dichloromethane)
- Methaemoglobin formation (aromatic amines)
- Anaemia (lead, benzene)
- Leukaemia (benzene)

2.0.9 Liver:

- Position of liver in the circulatory system
- Role in biotransformation and consequent vulnerability to toxic agents
- Structure of liver lobules
- Main agents which can cause liver damage (e.g. alcohol, chlorinated hydrocarbons, metal compounds)

2.0.10 Kidney:

- Structure and function
- Role in homeostasis and excretion
- Link to circulatory system
- Structure and role of nephrons
- Kidney as a target organ: Effects of Cadmium, Lead, Mercury, Organic compounds

2.0.11 Reproductive System

- Effects on unborn child: Heredity, Teratogenicity
- Interference with the male and female systems

3 Epidemiology (15%)

This section will provide candidates with suitable knowledge and training to ensure that the candidate can demonstrate their understanding in the following:

- 3.0.1
- Types of epidemiological study
 - Importance of study design
 - Definitions of cohort/case-referent, retrospective/prospective, cross-sectional/ longitudinal designs, mortality/morbidity ratios
 - Use of epidemiological data, limitations, and restrictions, confounding factors. Bradford Hill criteria
 - Limitations of epidemiological studies, importance of study size, link to exposure standards

4 Health Effects and Industrial Processes (30%)

This section will provide candidates with suitable knowledge and training to ensure that the candidate can demonstrate their understanding in the following:

4.0.1 Risk and Safety Phrases:

International system for Risk and safety phrases

4.0.2 Sources of information:

- Safety data sheets
- Literature
- National data bases including REACH

4.0.3 Gases:

Use a selection of the gases given below to illustrate the principal toxic effects (simple asphyxiation, chemical asphyxiation, upper and lower respiratory tract irritation, blood effects, lung damage, cancer) from exposure to gaseous substances. The occurrence of these gases and their common applications:

- Inert gases
- Carbon dioxide and carbon monoxide
- Hydrogen cyanide
- Ammonia
- Chlorine
- Hydrogen sulphide
- Oxides of nitrogen and ozone
- Acid gases (sulphur dioxide, hydrogen chloride, hydrogen fluoride)
- Metal hydrides

4.0.4 Vapours:

Describe the generic hazards of organic vapours (i.e. Narcosis, respiratory irritation, skin irritation and dermatitis, skin absorption, organ damage) and use some of the substances given below to illustrate these. The occurrence of these vapours and their common applications:

- Anaesthetic gases e.g. Halothane, Nitrous oxide
- Aniline and phenol
- Benzene, toluene, and xylene
- Formaldehyde
- Isocyanates
- Styrene
- Halogenated hydrocarbons
- vinyl chloride
- N-hexane
- Glycol ethers
- Acetone/MEK

4.0.5 Minerals, dusts, and particulate materials:

Minerals - Use the minerals given below to illustrate the principal toxic effects of such substances. The occurrence of these minerals and their common applications:

- Crystalline silica (quartz, cristobalite and tridymite)
- Asbestos (serpentine and amphibole)
- Machine-made mineral fibres (glass, rock, refractory ceramic fibre)

Organic and other dusts:

- Nanoparticles
- Flour and other food components (Industrial and manufacturing)
- Diesel fume
- Latex (Manufacturing and use)
- Enzymes (detergents and food industries)
- Physiological active materials (Pharmaceuticals)

4.0.6 Metals and their compounds:

Use some of the metals given below to illustrate the principal toxic effects (nuisance, respiratory effects, organ damage, lung damage, fibrosis, skin irritancy/sensitisation, systemic effects, cancer) from exposure to such metals and their compounds. The occurrence of these metals and their common applications:

- Arsenic
- Aluminium
- Beryllium
- Cadmium
- Chromium and nickel
- Cobalt
- Iron

- Lead (including differences between inorganic and organic lead compounds)
- Mercury
- Manganese
- Vanadium
- Zinc and copper

4.0.7 Common Industrial processes:

- Working with metals (Grinding, Machining, Welding)
- Surface coating and treatments (Chromium plating, galvanising etc.)
- Soldering
- Handling and processes involving solvents (open and closed systems. Degreasing, painting etc.)
- Handling of solids and powders

1.0.8 Specific industry profiles:

- Smelting and refining of iron and steel
- Foundries
- Mining and quarrying
- Oil and petroleum industry
- Pharmaceutical industry

5 An Outline to Biological Agents

Describe the principal toxic effects and sources of:

- Legionella and humidifier fever
- Infections of blood borne diseases (hepatitis and HIV)
- Zoonoses; definition, how infection can occur, common examples (anthrax, leptospirosis, salmonellosis).
- Bloodborne infections
- Moulds
- Pandemics
- Genetic modification

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Suggested References and Further Reading

- (1) WHO Guidelines on the prevention of toxic exposures
- (2) Patty's Industrial Hygiene and Toxicology
- (3) NIOSH, IARC and WHO criteria documents
- (4) Computer databases (RTECS, MEDLINE, TOXLINE, HSDB, HSELINE)
- (5) Controlling Skin Exposure to Chemicals and Wet-Work
- (6) Introduction to Toxicology
- (7) Industrial Toxicology

(8) Basic Epidemiology (WHO)

Course Length

This course will require at least **45** hours of study time, of which at least **37** hours will be taught (teaching and practical assessments) and **8** hours will be independent (in the candidates' own time).

Examinations and Assessment

Candidates are required to pass all of the following parts (A and B below) to be awarded this qualification.

A Practical Assessment

The practical assessment is conducted by the Tutor during the relevant part of the course for all candidates. This is to ensure that every candidate can demonstrate their individual ability and correct method.

The studies are designed by the course tutor(s) to assess basic skill and knowledge of each candidate and will include:

- An evaluation of available data to advise on a suitable exposure limit to be applied for a material (Safety data sheets etc.)
- A study should be a scenario study to evaluate potential exposure routes and the potential health consequences from a selected process.

Further information about the formative practical assessment is published in the following documents: Practical Evaluation Report which is available from www.bohs.org

B Written Examination

This is an open-book examination comprising of **40 (160 marks)** short-answer questions illustrated by photographs and diagrams as appropriate to be answered in **2** hours. Each question is worth **4** marks.

The examination covers all sections of the syllabus and is overseen by an invigilator.

The pass mark for this examination is 50 %

Certification

Candidates who pass all the parts (A, and B) within 12 months will be awarded the: '**M507 - Health Effects of Hazardous Substances**'