

## MODULE SYLLABUS

### M101 – HEALTH EFFECTS OF HAZARDOUS SUBSTANCES

**Aim:** 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.

On successful completion of this module the student should be able to:

- 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 main features of the principal target organs affected by hazardous substances at work, and the factors which influence the degree of harm;
- explain the main requirements of the Health and Safety at Work Act 1974 and the principal Regulations concerned with the assessment and control of hazardous substances and EU legislation;
- describe the main routes of exposure and toxic effects for hazardous substances commonly encountered in the workplace.

**Prior Knowledge:** 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 labeling and safety data sheets.

**Course Length:** It is envisaged that this course will be conducted over 5 days which includes the examination.

This course will require approximately 32 hours' study time, of which at least 24 hours will be taught (teaching and practical). The additional study time will be required in the candidates' own time.

Content:	Topic	Time Allocation
	<b>1 Basic Principles of Toxicology</b>	<b>20%</b>
	<b>2 Target Organs</b>	<b>20%</b>
	<b>3 Legal Aspects</b>	<b>10%</b>
	<b>4 Inorganic Materials</b>	<b>20%</b>
	<b>5 Organic Materials</b>	<b>20%</b>
	<b>6 Biological Agents</b>	<b>10%</b>

**Note:** Reference is made in this syllabus to HSE guidance or other documentation. This may not be the most up-to-date relevant publications from HSE/other sources and is intended as guidance for candidates only.

#### 1 Basic Principles of Toxicology (20%)

##### 1.1 Definitions

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

##### 1.2 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 site of storage; common examples of where materials are stored (eg. 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.

### 1.3 *Dose Response Relationships*

Meaning of dose response relationships.

Typical shape of dose response curve.

Concept of threshold.

Dose response curves without threshold.

Importance of slope of curve.

### 1.4 *Toxicity Testing*

Meaning of LD<sub>50</sub>, LD<sub>Lo</sub>, LC<sub>50</sub>, LC<sub>Lo</sub>, TD<sub>50</sub>, TD<sub>Lo</sub>, TC<sub>50</sub> and TD<sub>Lo</sub>.

Units used to express results of animal testing.

Skin irritancy testing - units used.

Limitations of toxicity testing data.

### 1.5 *Types of Combined Effects*

Addition, synergism, potentiation, antagonism.

### 1.6 *Sensitisers and Carcinogens*

Main target organs.

How sensitisation affects individuals.

Benign and malignant tumours.

Difficulties in identifying causal agents, long latency periods, common carcinogens (as defined by Schedule 1 of COSHH) and sensitisers (respiratory, animal allergy, skin - chromium).

Uncertainty about thresholds.

Mechanisms.

INRS Risk Phrases.

### 1.7 *Epidemiological Studies*

Meaning of epidemiology.

Types of epidemiological study.

Use of epidemiological data.

Limitations of epidemiological studies.

## 2 **Target Organs (20%)**

### 2.1 *Respiratory System*

**Structure:** The main regions of the respiratory system:

- Head airways region: role of turbinates, filtration mechanisms
- Tracheobronchial region: Structure, dimensions of air passages
- Alveolar region: Surface area, Retention time of particles, Lack of cilia

#### **Role of Mucociliary escalator**

Particle deposition and clearance.

Main deposition mechanisms; Interception, Impaction, Sedimentation, Diffusion.

Predominant deposition mechanisms for each of the three regions.

Particle size ranges from each of the three regions.

Stokes law: Factors included in the equation, Relevance of particle size.

Definition of aerodynamic diameter.

ISO Curves: Inspirable, thoracic and respirable curves, Shape of respirable curve.

#### **Role of Macrophages**

Absorption through the lungs.

Gases; Importance of solubility.

Particles: Those deposited in the alveoli, fate of particles deposited elsewhere, including absorption via digestive tract.

## **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.

Allergic conditions:

- Rhinitis - symptoms, non specific nature, wide range of agents
- Asthma - symptoms, common causes (isocyanates, solder fume, metals, latex, vegetable dusts, animal proteins, and enzymes)
- Allergic alveolitis - symptoms, causative agents for farmers lung, bagassosis, and pigeon fanciers lung
- Byssinosis - symptoms, main stages of textile process associated with disease

## 2.2 *Skin*

### **Structure**

The structure and function of the different layers and components:

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

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.

## 2.3 *Nervous System*

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.

Definitions, main mechanisms and common causes of:

- Damage to nerve cells (lead, mercury, n-hexane, manganese, DDT, carbon disulphide, methanol)
- Cell depolarisation (organochlorides and pyrethroid insecticides)
- Deactivation of cholinesterase (organophosphates and carbamate insecticides)
- Receptor antagonism (alkaloids)

## 2.4 *Circulatory System*

Composition of blood and role of constituents.

Blood as a target organ.

Definitions and common causes of:

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

## 2.5 *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 (eg. alcohol, chlorinated hydrocarbons, metal compounds).

2.6 *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.  
Main Agents causing physical damage: Deposition of oxalic acid following exposure to ethylene glycol.

2.7 *Reproductive System*  
Interference with male system - agents which can affect sperm production and infertility.  
Interference with female system - agents which can cause menstrual changes, infertility, miscarriage.  
Effects on unborn child: Heredity, Teratogenicity, Effects of lead.

### 3 **Legal Aspects (10%)**

#### 3.1 *Health and Safety and Work etc Act 1974 (HASAWA)*

The role of HASAWA as enabling legislation.  
Employer's duties, Employees duties Section 6.  
Legal status of ACOPs and Guidance Notes.

#### 3.2 *European Framework*

Status and requirements regarding implementation by Member States of Regulations and Directives.  
Implementation of Regulations and Directives in Great Britain.  
Indicative Occupational Exposure Limits.

#### 3.3 *The COSHH Regulations 2002 (as amended 2004) and ACOP(5)*

The role and scope of the Regulations (ie. to prevent occupational ill health).  
The provision of Regulations 6 to 13 and associated paragraphs of the General ACOP and Guidance.

#### 3.4 *The Control of Lead at Work Regulations 2002 and ACOP*

The role and scope of the Regulations.  
The provisions of Regulations 3 to 12 and the associated paragraphs of the ACOP and Guidance.

#### 3.5 *The Chemicals (Hazard Information and Packaging for Supply) Regulations 2002 (CHIP)*

The role and scope of the Regulations  
The provisions of Regulations 4-10 and the associated paragraphs of the ACOP and Guidance

### 4 **Inorganic Materials - In the context of common industrial processes (20%)**

#### 4.1 *Gases*

Use 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:

- 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

#### 4.2 *Minerals*

Use the minerals given below to illustrate the principal toxic effects of such substances:

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

### 4.3 *Metals and their Compounds*

Use 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 metals and their compounds.

- Arsenic
- Aluminium
- Beryllium
- Cadmium
- Chromium and nickel
- Cobalt
- Iron
- Lead (including differences between inorganic and organic lead compounds)
- Mercury
- Manganese
- Vanadium
- Zinc and copper

## 5 **Organic Materials - In the context of common industrial processes (20%)**

### 5.1 *Generic/Specific Hazards from Organic Vapours*

Describe the generic hazards of organic vapours (ie. Narcosis, respiratory irritation, skin irritation and dermatitis, skin absorption, organ damage) and use the substances given below to illustrate these:

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

## 6 **Biological Agents - In the context of common industrial processes (10%)**

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).

### **Recommended Documentation**

- (1) The Chemicals (Hazard Information and Packaging for Supply) Regulations 2002. (re-labeling and safety data sheets)
- (2) HSE Guidance Notes Environmental Hygiene (EH) Series. Relevant Guidance Notes in the series notably EH64 (2002). Summary Criteria for Occupational Exposure Limits
- (3) Relevant NIOSH, IARC and WHO criteria documents
- (4) Patty's Industrial Hygiene and Toxicology
- (5) Computer databases (RTECS, MEDLINE, TOXLINE, HSDB, HSELINE, CDROMS, Internet Source)
- (6) The Control of Lead at Work Regulations 2002 ACOP and Guidance
- (7) The COSHH Regulations 2002 (as amended 2004). ACOP and Guidance (Fifth Edition)
- (8) HSE Guidance Note L8 (2000) Legionnaires Disease
- (9) HSE Guidance Note HSG174 (1997) Anthrax