

Course Specification

Course Title	Health Effects of Hazardous Substances
Code	W507
Level	Intermediate
Pre-requisites	None

Course Manual	Available from ohtatraining.org
Coordinating Editor	Alan Weinrich
Approval Date	August 2009
Review Date	August 2012

Aims

This course aims to:

Provide an introduction to the principles of toxicology, physiology and epidemiology. The main types of harmful effects to target organs from exposure to chemical hazards at work, and the hazards associated with common hazardous substances.

Learning Outcomes

On completing this course successfully, 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.
- Describe the main routes of exposure and toxic and health effects for hazardous substances commonly encountered in the workplace.
- Carry out basic interpretation of the results from epidemiological studies

Course Format

Normally run as a 5-day taught course [minimum 45 hours including lectures, tutorials, practical/demonstration sessions, guided reading, overnight questions and examination]. There will be a 40 short answer question "open book" examination with an allowed time of 120 minutes.

Content	Topic	Time Allocation
	1 Basic Principles of Toxicology	25%
	2 Physiology and Target Organs	30%
	3 Epidemiology	15%
	4 Health Effects and Industrial Processes Biological Agents (outlined as annex*)	30%

Note: Reference is made to standards and good practice documentation. This may not be the most up to date relevant publications and is intended as guidance for candidates only.

Detailed Course Content

1 Basic Principles of Toxicology (25%)

- 1.1 *Definitions*
 - 1.1.1 Acute, Chronic, Local, Systemic, Allergic reaction, Sensitiser, Carcinogen, Mutagen, Teratogen, Xenobiotic, Stochastic, Non-Stochastic
- 1.2 *Basic Pharmacokinetics*
 - 1.2.1 Absorption: Routes of absorption for substances, when ingestion can occur, situations where skin absorption and penetration can occur
 - 1.2.2 Distribution: main distribution pathways, blood, lymphatic system
 - 1.2.3 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)
 - 1.2.4 Biotransformation: Meaning of biotransformation, where biotransformation occurs, how biotransformation can initiate or enhance toxic effects (examples - benzene, dichloromethane, methanol)
 - 1.2.5 Elimination: Definition of biological half life, wide variation of half lives, shape of curve
- 1.3 *Dose Response Relationships*
 - 1.3.1 Meaning of dose response relationships
 - 1.3.2 Typical shape of dose response curve
 - 1.3.3 Concept of threshold and no-observed adverse effect level
 - 1.3.4 Dose response curves without threshold
 - 1.3.5 Importance of slope of curve
- 1.4 *Toxicity Testing*
 - 1.4.1 Meaning of LD₅₀, LD_{Lo}, LC₅₀, LC_{Lo}, TD₅₀, TD_{Lo}, TC₅₀ and TD_{Lo}
 - 1.4.2 Units used to express results of animal testing
 - 1.4.3 Types of toxicity testing – toxicokinetic studies, acute toxicity studies, sensitisation studies, repeated dose toxicity studies, genotoxicity studies, reproductive and developmental toxicity studies, carcinogenicity studies
 - 1.4.4 Uses of toxicological data and estimation of safe human dose
 - 1.4.5 Limitations of toxicity testing data.
- 1.5 *Types of Combined Effects*
 - 1.5.1 Addition, synergism, potentiation, antagonism, independent
- 1.6 *General Health Effects*
 - 1.6.1 Asphyxia
 - 1.6.2 Irritation
 - 1.6.3 Narcosis
 - 1.6.4 Toxicity
 - 1.6.5 Carcinogens
 - Basic mechanisms of Carcinogenicity [geneotoxicity, Irritant etc.]
 - Benign and malignant tumours
 - Difficulties in identifying causal agents, long latency periods
 - IARC classifications
 - 1.6.6 Sensitisers
 - How sensitisation affects individuals
 - Sensitisers (respiratory, animal allergy, skin - chromium).
 - Uncertainty about thresholds
 - Mechanisms of sensitisation and assessment methods
 - 1.6.7 Reproductive Effects
 - Teratogens

2 Physiology and Target Organs (30%)

- 2.1 *Respiratory System*
 - 2.1.1 The main regions of the respiratory system:
 - Head airways region: role of turbinates, filtration mechanisms

- Tracheobronchial region: Structure, dimensions of air passages
 - Mucociliary escalator
 - Alveolar region: Surface area, Retention time of particles, Lack of cilia
- 2.1.2 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
- 2.1.3 Gases and Vapours
- Absorption through the lungs
 - Gases; Importance of solubility
- 2.1.4 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.)
 - 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 { 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 testings, Blood iGe analysis etc
- 2.2 *Skin*
- 2.2.1 *Structure*
- The structure and function of the different layers and components:
- Stratum corneum and epidermis
 - Dermis
 - Hair follicles
 - Sweat glands
 - Nerves
 - Fat
- 2.2.2 Mechanisms of cutaneous protection against chemical penetration and biological agents
- 2.2.3 The skin as a target organ
- 2.2.4 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*
- 2.3.1 Central and peripheral nervous systems: definitions, roles, structure of nerve cells, transmission of nerve impulses; transmission along cells, transmission across synaptic gap
- 2.3.2 Nervous system as a target organ
- 2.3.3 Role of volatile organic compounds as depressants
- 2.3.4 Definitions, main mechanisms and common causes of:
- Damage to nerve cells (lead, mercury, n-hexane, manganese.)
 - Deactivation of cholinesterase (organophosphates)

- 2.4 *Circulatory system*
 - 2.4.1 Composition of blood and role of constituents
 - 2.4.2 Blood as a target organ
 - 2.4.3 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*
 - 2.5.1 Position of liver in the circulatory system
 - 2.5.2 Role in biotransformation and consequent vulnerability to toxic agents
 - 2.5.3 Structure of liver lobules
 - 2.5.4 Main agents which can cause liver damage (eg. alcohol, chlorinated hydrocarbons, metal compounds)
- 2.6 *Kidney*
 - 2.6.1 Structure and function
 - 2.6.2 Role in homeostasis and excretion
 - 2.6.3 Link to circulatory system
 - 2.6.4 Structure and role of nephrons
 - 2.6.5 Kidney as a target organ: Effects of Cadmium, Lead, Mercury, Organic compounds
- 2.7 *Reproductive System*
 - 2.7.1 Effects on unborn child: Heredity, Teratogenicity
 - 2.7.2 Interference with the male and female systems

3 Epidemiology (15%)

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

4 Health Effects and Industrial Processes (30%)

- 4.1 *Risk and Safety Phrases*
 - 4.1.1 International system for Risk and safety phrases
- 4.2 *Sources of information*
 - 4.2.1 Safety data sheets
 - 4.2.2 Literature
 - 4.2.3 National data bases including REACH
- 4.3 *Gases*
 - 4.3.1 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 should be included
 - 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

4.4 *Vapours*

4.4.1 Describe the generic hazards of organic vapours (ie. 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 should be included.

- 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

4.5 *Dusts and particulate materials*

4.5.1 Minerals

Use the minerals given below to illustrate the principal toxic effects of such substances: The occurrence of these minerals and their common applications should be included

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

4.5.2 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]

4.6 *Metals and their compounds*

4.6.1 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 should be included

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

4.7 *Common Industrial processes*

4.7.1 Working with metals [Grinding, Machining, Welding]

4.7.2 Surface coating and treatments [Chromium plating, galvanising etc.]

4.7.3 Soldering

4.7.4 Handling and processes involving solvents [open and closed systems. Degreasing, painting etc.]

4.7.5 Handling of solids and powders

4.8 *Specific industry profiles*

4.8.1 Smelting and refining of iron and steel

4.8.2 Foundries

4.8.3 Mining and quarrying

- 4.8.4 Oil and petroleum industry
- 4.8.5 Pharmaceutical industry

Biological Agents (Outlined as Annex*)

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

[* It should be noted that the outline of Biological Agents is provided as an Annex for reference purposes only as part of the course manual. The student's understanding of this section of the syllabus is not included in the assessment of this module. The inclusion of this section is simply to make students aware that consideration of exposures to Biological Agents could be important in certain workplace situations.]

Learning and Teaching Activities

Learning Time

Scheduled contact hours: (Note these timings are indicative only)	Lectures	16
	Seminars	2
	Practical Sessions	8
	Tutorials	8
	Examinations (including preparation)	3
	Other Scheduled Time	
Guided independent study Note: include in guided independent study preparation for scheduled sessions, follow up work, wider reading or practice, revision	Independent Coursework	8
	Independent Laboratory Work	
	Other Non-scheduled Time	
Total Hours		45

Assessment Details

Methods of Assessment	Practical Assessment	Written Examination
Grading Mode	Formative	Summative
Weighting %	NA	100
Pass Mark	NA	Set by examining body
Outline Details	<p>All candidates must participate in the practical case studies and demonstrate the required skills.</p> <p>The case studies should be designed by the course tutor(s) to test the basic skill and knowledge of each of the candidates.</p> <p>One study should be an evaluation of available data to advise on a suitable exposure limit to be applied for a material [Safety data sheets etc.] the other study should be a scenario study to evaluate potential exposure routes and the potential health consequences from a selected process.</p> <p>Full details of the practical requirements and the individual candidate reports forms etc are available in document JG.2 Practical Evaluation Report which is available from www.bohs.org and www.ohattraining.org</p>	<p>40 short answer questions to be answered in 120 minutes. The questions require candidates to write short answers which will require no more than the box provided but may include multiple answers. Some questions may require calculations.</p> <p>Students can only refer to the W507 student manual during the examination.</p>

Is the student required to pass ALL elements of assessment in order to pass the course? Yes

Indicative Course Materials and Reading

ISBN Number	Author	Date	Title	Publisher
			W507 Health Effects of Hazardous Substances Student Manual. Downloadable for free from www.ohattraining.org	OHTA
			WHO Guidelines on the prevention of toxic exposures	WHO
978 047 1700579			Patty's Industrial Hygiene and Toxicology [5th Edition]	CRC
			NIOSH, IARC and WHO criteria documents	
			Computer databases (RTECS, MEDLINE, TOXLINE, HSDB, HSELINE, CDROMS)	
978-1-906674-00-7	Rajadurai Sithamparanadarajah		Controlling Skin Exposure to Chemicals and Wet-Work	BOHS
978 041 5247634	J.A.Trimbrell		Introduction to Toxicology, 3rd edition	Taylor & Francis
978 047 1459232	P.L.Williams & J.L.Burson		Industrial Toxicology	Van Nostrand Reinhold
92 4154707 3	Bonita, Beaglehole & Kjeellstrom	2006	Basic Epidemiology Second edition [Also available as e-book]	WHO