

BENZENE

BASELINE HEALTH MONITORING BEFORE STARTING WORK IN A BENZENE PROCESS

1. **Collection of demographic data**
2. **Work history**
3. **Medical history**
4. **Physical examination**

A physical examination will be conducted only if indicated by work and medical history

5. **Investigation**

A blood sample for haematological profile will be used to test the worker's baseline exposure.

DURING EXPOSURE TO A BENZENE PROCESS

6. **Biological exposure**

S-Phenylmercapturic acid (S-PMA) and trans-trans-muconic acid (tt-MA) are two minor urinary metabolites of benzene which can be used as a measure of exposure to benzene. S-PMA is a highly specific marker of benzene exposure. It has greater specificity than other markers like phenol which is unsuitable for benzene monitoring unless at very high levels. The metabolite (tt-MA) is useful for benzene monitoring at exposures < 0.5 ppm but has the interference of sorbic acid and sorbitol found in certain foods including cheese, syrup, jelly, cake, dry fruits and soft drinks.

A spot urine test can be used to determine levels of S-PMA relative to creatinine. A spot urine test for S-PMA should be performed at the end of a work shift. S-PMA has a half-life of nine hours in urine.

A spot urine test showing a level of S-PMA of 25 µg/g creatinine indicates the worker may have been occupationally exposed to benzene¹. If this occurs, the registered medical practitioner should consider a recommendation to remove the worker from the benzene work, taking into account other benzene exposure factors including the confounding factors described below. The person controlling the business or undertaking should also review control measures.

If spot urine testing demonstrates exposure to benzene is consistent with occupational exposure, the registered medical practitioner should also consider taking a blood sample to compare the haematological profile with the worker's baseline haematological profile determined at the beginning of the health monitoring process. For people exposed to relatively high levels of benzene, complete blood analysis can be used to monitor possible changes related to exposure.

■ 1 The WorkCover NSW Biological Occupational Exposure Limit (BOEL) for benzene is 11.8 µmol S-PMA/mol creatinine in urine (which is equivalent to 25 µg/L in mass units), while the American Conference of Governmental Industrial Hygienists (ACGIH) biological exposure limits for benzene are 500 µg/g creatinine for tt-MA and 25 µg/g creatinine for S-PMA. WorkCover NSW BOEL and ACGIH biological exposure limit for S-PMA are about the same as there is approximately 1g creatinine/l urine.

7. Confounding factors

As tobacco smoke contains benzene, inhalation of tobacco smoke will cause elevated background values of S-PMA. The normal background level of S-PMA for a non-smoker is around 2.0 µg/g creatinine and 3.6 µg/g creatinine for a smoker.

AT TERMINATION OF WORK IN A BENZENE PROCESS

8. Final medical examination

A final medical examination will be carried out. A blood sample should be taken and results compared with the worker's baseline haematological profile. Workers with haematological abnormalities should be advised to seek continuing medical monitoring.

SUPPLEMENTARY INFORMATION ON BENZENE

Benzene, an aromatic hydrocarbon, is a natural component of crude and refined petroleum.

9. Work activities that may represent a high risk exposure

Examples of work activities involving benzene which may require special attention when assessing exposure include:

- refining operations, for example maintenance of equipment used for handling benzene-containing refinery streams and sampling benzene-containing refinery streams in open containers
- chemical manufacturing
- handling of petrol, that is, storage and transport, for example by filling rail tankers and top-filling road tankers with gasoline
- motor vehicle repair - working on vehicle fuel systems
- plastics and rubber manufacturing
- steel production - by-product of coal coking
- firefighting - emission from burning synthetic polymers like polyvinyl chloride and urethane foam.

10. Non-work sources of exposure

- cigarettes
- vehicle exhaust
- petrol evaporation

Benzene, together with the other aromatic hydrocarbons toluene, ethylbenzene and the xylenes, is a major component of petrol. The aromatics increase the octane rating of petrol to the level needed by engines to provide acceptable fuel economy and performances. Of these aromatics, benzene is normally a minority component². Benzene can escape into the air, particularly from vehicle fuel systems and from filling stations. The major source of exposure for the general population is from vehicle exhausts because in addition to the benzene actually present in petrol, it is also produced by chemical reactions during combustion in the engine.

■ 2 Australian Government Department of Sustainability, Environment, Water, Population and Communities. www.environment.gov.au.

Cigarette smoke contains benzene and the World Health Organisation has estimated a benzene intake of 30 µg per cigarette. Passive smoking particularly indoors will also contribute to benzene intake of non-smokers.

Food and drinking water contains either no or negligible amounts of benzene.

POTENTIAL HEALTH EFFECTS FOLLOWING EXPOSURE TO BENZENE

11. Route of entry into the body

The routes of benzene entry into the body are through inhalation, ingestion and percutaneous absorption.

12. Target organ/effect

Blood/bone marrow – bone marrow depression (anaemia, leucopenia, thrombocytopaenia or pancytopenia) and leukaemia, particularly acute myeloid leukaemia, and possibly an increased risk of non-Hodgkin's lymphoma and multiple myeloma.

CNS – acute CNS depression with drowsiness, dizziness, headaches and vomiting, and chronic solvent neurotoxicity.

Respiratory system – irritation.

Skin – irritation.

Eyes – irritation.

13. Acute effects

Acute exposure to high concentrations of benzene vapours can result in irritation of the skin, eyes and respiratory system and in central nervous system depression and arrhythmias.

Central nervous system

The acute effects from exposure to high levels of benzene, that is 500-1000 ppm, are central nervous system depression, narcosis, unconsciousness, coma and death. Benzene concentrations of about 20 000 ppm are fatal to humans within five to 10 minutes.

Exposures of 50-150 ppm for several hours can cause headaches, lassitude and general weakness. Symptoms of CNS depression include headache, nausea and vomiting, dizziness, slurred speech, euphoria, fatigue, weakness, irritability, disorientation, confusion, loss of consciousness and death.

Respiratory system

All organic solvents irritate the respiratory tract to some degree as a consequence of the defatting action of solvents. Respiratory tract irritation from solvents is usually confined to the upper airways, including the nose and sinuses. Overexposure can cause pulmonary oedema, exacerbation of asthma or, less commonly, induction of reactive airway dysfunction. Symptoms of irritation of the upper respiratory tract are marked by sore nose and throat, cough and possibly chest pain. If the eyes are not protected by vapour goggles irritation of the eyes may result.

14. Chronic effects

Benzene is both haematotoxic and leukaemogenic by a range of mechanisms involving the bone marrow haematopoietic cell populations. The haematotoxic effects of benzene largely involve cytotoxic damage to the bone marrow stem cells. Chronic exposure to levels of 100-500 ppm have resulted in depression of bone marrow haemopoiesis leading to anaemia, leucopenia, thrombocytopenia or pancytopenia.

For bone marrow depression, the lowest observed adverse effect level in humans is 7.6 parts per million (ppm) based on minimal blood count changes in otherwise healthy workers.

Metabolites of benzene are thought to be responsible for most of the toxic effects associated with benzene exposure. The molecular mechanisms underlying leukaemogenesis appear to involve clastogenic effects. Leukaemia cell populations are monoclonal (resulting from a single cell or cell type) and are found to have distinct chromosomal abnormalities thought to be due to interference by benzene metabolite with chromosomal separation during cell division.

Benzene may be present as a contaminant in mixed solvents and health effects may be due to exposure to the mixture.

The chronic effects of exposure to organic solvents include:

CNS

Neurotoxicity with symptoms including personality or mood changes, fatigue, decreased motivation, difficulty in concentration and impairment in memory.

SKIN

Almost all organic solvents are primary skin irritants as a result of defatting of the skin. Up to 20% of cases of work-related dermatitis are caused by solvents.

LIVER

Organic solvents may cause hepato-cellular damage if there is exposure in sufficient dose for sufficient duration.

KIDNEYS

There are reports of renal effects in exposed workers. Chronic exposure to a number of solvents may result in mild renal tubular dysfunction evidenced by impaired re-absorption of proteins, glucose and amino acids by the proximal tubule. A characteristic sign of renal tubular dysfunction is an increased excretion of low molecular weight proteins in the urine including β 2-microglobulin.

15. Carcinogenicity

Acute myeloid leukaemia has been demonstrated to occur more frequently in workers exposed to benzene at work. Several reports suggest exposure to benzene may be related to non-Hodgkins lymphoma and multiple myeloma.

16. Carcinogen and germ cell mutagen classification³

Benzene is classified according to the GHS as a Carcinogenicity Category 1A (May cause cancer) and Germ Cell Mutagenicity Category 1B (May cause genetic defects).

■ 3 This classification information is provided on an advisory basis and is taken from the European Union's Annex VI to Regulation (EC) No 1272/2008, updated by the 1st Adaption to Technical Progress to the Regulation. Other hazard classes and categories may apply – see <http://esis.jrc.ec.europa.eu/index.php?PGM=cla>. These classifications are legally binding within the European Union.

FURTHER READING

Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Benzene*, Agency for Toxic Substances and Disease Registry, United States Department of Health and Human Services, Public Health Service, Atlanta, 2007.

American Conference of Governmental Industrial Hygienists (ACGIH), *Documentation of the Threshold Limit Values and Biological Exposure Indices, Benzene*, 7th edition, Cincinnati, 2011.

American Petroleum Institute, *Biological mechanistic considerations relevant to benzene induced leukemogenesis*, ACGIH TLV Committee, 1996; 9/9/96.

Institute of Petroleum, *Guidelines for Health Surveillance and Biological Monitoring for Occupational Exposure to Benzene*, Occupational and Environmental Medical Subcommittee of the Institute of Petroleum, London, 1993.

International Programme on Chemical Safety, *Environmental Health Criteria 150: Benzene*, International Programme on Chemical Safety, World Health Organization, Geneva 1993.

National Industrial Chemicals Notification and Assessment Scheme, *Benzene, Priority Existing Chemical Assessment Report No.21*, Sep 2001.

Oil Companies' European Organisation for Environmental and Health Protection, *Guidelines for the Health Surveillance of Workers Exposed to Benzene in the Petroleum Industry Report No. 93/59*, Oil Companies' European Organisation for Environmental and Health Protection, Brussels, 1993.

HEALTH MONITORING REPORT BENZENE

This health monitoring report is a confidential health record and must not be disclosed to another person except in accordance with the Work Health and Safety Regulations or with the consent of the worker.

There are two sections. Complete both sections and all questions if applicable.

Section 1 is to be forwarded to the PCBU who has engaged your services. A copy of laboratory report(s) must be attached > > >

Section 2 may contain confidential information which may not be relevant to the health monitoring program being carried out. This section should be retained by the medical practitioner. Information which is required to be given to the PCBU should be summarised in part 7 of section 1.

SECTION 1 - THIS SECTION TO BE RETURNED TO THE PCBU			
1. PERSON CONDUCTING A BUSINESS OR UNDERTAKING			
Company / Organisation name:			
Site address:			
Suburb:			Postcode:
Site Tel:	Site Fax:	Contact Name:	
2. OTHER BUSINESSES OR UNDERTAKINGS ENGAGING THE WORKER			
Company / Organisation name:			
Site address:			
Suburb:			Postcode:
Site Tel:	Site Fax:	Contact Name:	
3. WORKER (✓) all relevant boxes			
Surname:		Given names:	
Date of birth: DD/MM/YYYY		Sex: <input type="checkbox"/> Male <input type="checkbox"/> Female	
Address:			
Suburb:			Postcode:
Current Job:		Tel(H):	Mob:
Date started employment : DD/MM/YYYY			
4. EMPLOYMENT IN BENZENE RISK WORK (✓) all relevant boxes			
1. <input type="checkbox"/> New to benzene work			
2. <input type="checkbox"/> New worker but not new to benzene work			
3. <input type="checkbox"/> Current worker continuing in benzene work			
4. Worked with benzene since DD/MM/YYYY			
5. Satisfactory personal hygiene (for example nail biting, frequency of hand washing)		<input type="checkbox"/> Yes	<input type="checkbox"/> No
6. Risk assessment completed		<input type="checkbox"/> Yes	<input type="checkbox"/> No

5. WORK ENVIRONMENT ASSESSMENT		(✓) all relevant boxes	
Date of assessment: DD/MM/YYYY			
Benzene Industry			
<input type="checkbox"/> Refining	Controls:		
<input type="checkbox"/> Chemical Industry	Wear gloves	<input type="checkbox"/> Yes	<input type="checkbox"/> No
<input type="checkbox"/> Petrol Industry	Respirator use	<input type="checkbox"/> Yes	<input type="checkbox"/> No
<input type="checkbox"/> Automotive Industry	Local exhaust ventilation	<input type="checkbox"/> Yes	<input type="checkbox"/> No
<input type="checkbox"/> Plastics/Rubber Manufacturing	Overalls / work clothing	<input type="checkbox"/> Yes	<input type="checkbox"/> No
<input type="checkbox"/> Steel Industry	Laundering by employer	<input type="checkbox"/> Yes	<input type="checkbox"/> No
<input type="checkbox"/> Emergency Services	Wash basins & showers (with hot & cold water)	<input type="checkbox"/> Yes	<input type="checkbox"/> No
<input type="checkbox"/> Other (specify):	Smoking or eating in workshop	<input type="checkbox"/> Yes	<input type="checkbox"/> No
	Personal hygiene:		
	Clean Shaven	<input type="checkbox"/> Yes	<input type="checkbox"/> No
	Shower & change into clean clothes at end of shift	<input type="checkbox"/> Yes	<input type="checkbox"/> No
6. BIOLOGICAL MONITORING RESULTS Include at least the previous two test results (if available)			
Date	Tests performed	Recommended Action and/or Comment	
1. DD/MM/YYYY			
2. DD/MM/YYYY			
3. DD/MM/YYYY			
4. DD/MM/YYYY			
5. DD/MM/YYYY			
6. DD/MM/YYYY			
7. DD/MM/YYYY			
8. DD/MM/YYYY			

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7. RECOMMENDATIONS (by Medical Practitioner)		(✓) all relevant boxes
1. <input type="checkbox"/> Suitable for work with benzene		
2. <input type="checkbox"/> Counselling required		
3. <input type="checkbox"/> Review workplace controls		
4. <input type="checkbox"/> Repeat health assessment in _____ month(s) / _____ week(s)		
5. <input type="checkbox"/> Removal from work with benzene		On DD/MM/YYYY
6. <input type="checkbox"/> Medical examination by Medical Practitioner		On DD/MM/YYYY
7. <input type="checkbox"/> Fit to resume work		From DD/MM/YYYY
8. <input type="checkbox"/> Referred to Medical Specialist (respiratory/ dermatology/other)		On DD/MM/YYYY
Specialist's name:		
Additional comments or recommendations arising from health monitoring:		
Medical Practitioner (responsible for supervising health monitoring)		
Name:		Date: DD/MM/YYYY
Signature		
Tel:	Fax:	Registration Number:
Medical Practice:		
Address:		
Suburb:		Postcode:

SECTION 2 - THIS SECTION TO BE RETAINED BY THE MEDICAL PRACTITIONER			
1. PERSON CONDUCTING A BUSINESS OR UNDERTAKING			
Company / Organisation name:			
Site address:			
Suburb:			Postcode:
Site Tel:	Site Fax:	Contact Name:	
2. OTHER BUSINESSES OR UNDERTAKINGS ENGAGING THE WORKER			
Company / Organisation name:			
Site address:			
Suburb:			Postcode:
Site Tel:	Site Fax:	Contact Name:	
3. WORKER (✓) all relevant boxes			
Surname:		Given names:	
Date of birth: DD/MM/YYYY	Sex:	<input type="checkbox"/> Male	<input type="checkbox"/> Female
		<input type="checkbox"/> Pregnant/Breast Feeding?	
Address:			
Suburb:			Postcode:
Current Job:	Tel(H):	Mob:	
Date started employment : DD/MM/YYYY			
4. GENERAL HEALTH ASSESSMENT (if applicable)			
Symptoms of:	Comments	Further testing?	
Skin disorders		<input type="checkbox"/> Yes	<input type="checkbox"/> No
Headaches, dizziness		<input type="checkbox"/> Yes	<input type="checkbox"/> No
Respiratory disorders		<input type="checkbox"/> Yes	<input type="checkbox"/> No
Irritation of eyes, nose or throat		<input type="checkbox"/> Yes	<input type="checkbox"/> No
Cough		<input type="checkbox"/> Yes	<input type="checkbox"/> No
CNS		<input type="checkbox"/> Yes	<input type="checkbox"/> No
Others		<input type="checkbox"/> Yes	<input type="checkbox"/> No

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Height ____cm Weight ____kg Bp ____/____ mmHg		<input type="checkbox"/> Yes <input type="checkbox"/> No
5. OTHER MEDICAL HISTORY, FAMILY MEDICAL HISTORY, CURRENT MEDICATION, COMMENTS, TESTS OR RECOMMENDATIONS (use separate sheet if necessary)		
Medical Practitioner (responsible for supervising health monitoring)		
Name:	Signature	Date: DD/MM/YYYY
Tel:	Fax:	Registration Number:
Medical Practice:		
Address:		
Suburb:		Postcode: