

ARSENIC (INORGANIC)

BASELINE HEALTH MONITORING BEFORE STARTING WORK IN AN INORGANIC ARSENIC PROCESS

Baseline health monitoring of the worker is required before the worker starts work in an inorganic arsenic process so that changes to the worker's health during inorganic arsenic work can be detected.

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

A physical examination will be conducted, with an emphasis on the peripheral nervous system and skin.

- 5. Investigation**

A baseline level of arsenic in urine will be determined. The preferred method is by separation of the dietary arsenic from the inorganic arsenic and its metabolites by chromatographically separating the arsenic species, or by liquid-liquid extraction. Chromatographic separation is the superior technique as liquid-liquid extraction does not totally separate dietary arsenic from the inorganic arsenic metabolites and a small false positive may result.

It is recommended the test result not be reported adjusted to creatinine, however, the creatinine result should be provided separately in order to assist with the interpretation of the test result.

Where separation of dietary arsenic from the inorganic arsenic and its metabolites is not available total urinary arsenic, corrected for creatinine, may be determined. However, results using this method may be distorted where workers have recently eaten seafood or smoke heavily. In this instance, workers should be advised to abstain from seafood (including fish sauce, shrimp paste, fish and shellfish) and red wine for three days and seaweed for at least four days prior to urine collection.

DURING EXPOSURE TO AN INORGANIC ARSENIC PROCESS

- 6. Monitoring exposure to inorganic arsenic**

The registered medical practitioner will assess exposure to inorganic arsenic through urinary inorganic arsenic testing, preferably by separation of the dietary arsenic from the inorganic arsenic and its metabolites.

Testing should be carried out at 90 day intervals, unless results consistently show urinary arsenic levels are low in which case the medical practitioner may decide less frequent testing is necessary. Tests should be done at end of a work shift at the end of the work week.

Where inorganic arsenic and its metabolites are present in urine above 0.47 $\mu\text{mol/L}$ (35 $\mu\text{g/L}$) this indicates the worker may have been exposed to arsenic at work. In this instance the following actions will be carried out:

- a repeat urine analysis for inorganic arsenic and its metabolites will be performed at the same time of the day to confirm test results
- a medical examination will be conducted, with particular emphasis on the peripheral nervous system and skin

- the person conducting a business or undertaking will be advised to:
 - review control measures at the workplace
 - carry out recommended remedial action
 - inform the worker of the results of the health monitoring.

Exposure to arsenic at the current exposure standard of 0.05 mg/m³ TWA would be expected to result in a urinary arsenic level of approximately 54 µg inorganic As/L, as the sum of arsenic metabolites in the urine.

It is recommended biological monitoring is conducted as soon as practicable after the last potential exposure because inorganic arsenic in urine has a half-life of one to four days. The half-life needs to be taken into account during biological monitoring.

REMOVAL FROM WORK

Where a medical examination indicates the worker is displaying symptoms of exposure to arsenic, the medical practitioner should recommend the worker be removed from arsenic work. The worker must not return to inorganic arsenic work until they have been assessed as medically fit to return to work by the medical practitioner supervising the health monitoring.

Where total urinary arsenic is determined workers should be advised to abstain from seafood and red wine for three days and seaweed for at least four days prior to urine collection. Where test results show total urinary arsenic above 35 µg/L the sample should be tested for inorganic arsenic and its metabolites.

Since many of the health effects resulting from exposure to arsenic are chronic, for example carcinogenicity, the worker will not always display symptoms of exposure. So a removal level based on biological monitoring of urinary arsenic should be considered.

AT TERMINATION OF WORK IN AN INORGANIC ARSENIC PROCESS

7. Final medical examination

A final medical examination will be conducted and will include skin and neurological checks.

8. Continuing Medical Surveillance

People with skin or neurological signs due to arsenic should be advised to seek continuing medical surveillance.

SUPPLEMENTARY INFORMATION ON INORGANIC ARSENIC

Arsenic is a metalloid widely distributed in the earth's crust. It occurs in trace quantities in rock, soil, water and air. It is a common contaminant in most mineral ores. The main non-work source of arsenic is seafood. Arsenic exists in three common valence states:

- the metalloid (As⁰)
- arsenite (trivalent state, As³⁺)
- arsenate (pentavalent state, As⁵⁺).

9. Work activities that may represent a high risk exposure

Examples of work activities involving inorganic arsenic which require special attention when assessing exposure include:

- manufacture of arsenic compounds, the most important of which is the trioxide (As_2O_3)
- formulation and application of insecticides (lead arsenate, calcium arsenate, arsenic trioxide and pentoxide), weed killers, rat poison, fungicides (copper aceto-arsenite or Paris green), wood preservative like copper chrome arsenic (arsenic pentoxide); in the past used as cattle dip (arsenic trioxide) and sheep dip (sodium arsenite)
- production of pigments (arsenic trisulphide and trioxide), ceramic enamels and anti-fouling paints (arsenic trioxide)
- hide preservation in the leather industry (arsenic trioxide)
- hardening copper, lead and other alloys
- copper, zinc and lead smelting.

Special attention should also be given to acute exposures that may occur in the above processes.

Arsenic from occupational sources occurs predominantly as As(III) and As(V). Both As(III) and As(V) are metabolised in the body and can be excreted in urine as the less toxic compounds, dimethyl arsinic acid (DMAv) and monomethyl arsonic acid (MMAv). In people exposed to high levels of As(III) or As(V) not all of the inorganic species will be converted in the body to MMAv or DMAv, and therefore As(III) and As(V) may also be excreted in urine. Total inorganic arsenic test result is the summation of MMAv + DMAv + As(III) + As(V).

10. Non-work sources

Fish, shellfish and seaweed contain organic arsenic compounds like arsenobetaine (AB) and a small amount of DMAv, which are excreted in urine unchanged. Seaweed can be consumed in the form of kelp as a dietary supplement or in Japanese cuisine. Seaweed contains a significant amount of arsenic predominantly in the form of arsenosugars. Urine total arsenic may reach levels of 1000 $\mu\text{g/g}$ creatinine a few hours after eating a seafood meal with virtually all of this being in the form of organic arsenic.

MMAv is the metabolite from exposure to As(III) or As(V). DMAv is present in seafood and is the main metabolite from exposure to As(III) or As(V). As(III) and As(V) will be found present in the urine when moderate to high exposures have been experienced and the sample has been taken within 24 hrs of exposure.

Arsenobetaine is only present in seafood. Urinary excretion proportions are approximately 15-25% MMAv, 40-75% DMAv and 20-25% As(III) and/or As(V). These proportions can vary depending on exposed species, time after exposure and dose level.

11. Potential Health Effects Following Use Of Inorganic Arsenic

The relative toxicity of arsenic containing compounds depends primarily on its chemical type, valence state, solubility and physical form. Soluble compounds of arsenic, for example sodium arsenite, are more toxic than insoluble compounds like arsenic sulphide.

The toxicity of trivalent arsenite, for example arsenic trioxide or arsenic trichloride, is typically greater than that of pentavalent arsenate (arsenic pentoxide). Arsine gas (AsH_3) produces clinical symptoms different from other arsenic compounds and is the most toxic arsenic compound.

12. Route of entry into the body

The primary route of inorganic arsenic entry into the body is through inhalation of arsine gas or airborne arsenic fumes or dusts. The particle size of airborne arsenic determines whether arsenic will reach the lower respiratory tract or be deposited in the upper airways and be swallowed after mucociliary clearance. In addition, soluble forms of inorganic arsenic compounds are well absorbed from the gastro-intestinal tract (60-90 per cent). Some arsenic compounds, for example arsenic acid and arsenic trichloride, may be absorbed percutaneously. Inorganic arsenic does not cross the blood-brain barrier but does cross the placenta.

13. Target organ/effect

Skin and mucous membranes – dermatitis, skin ulcers, hyperpigmentation, keratoses, skin cancer.

Nervous system – peripheral neuropathy.

Respiratory tract – irritation of nose, throat and lungs, perforation of nasal septum, lung cancer.

Gastrointestinal – irritation.

Circulatory system – peripheral vascular disease.

Bone marrow – pancytopenia.

Liver – hepatocellular damage.

Hearing – potential ototoxin.

14. Acute effects

Acute clinical symptoms from arsenic exposure will vary widely with the type and chemical state of the arsenic involved. Acute effects are generally the result of short-term exposures to high concentrations of arsenic.

Arsine gas is a potent haemolytic poison in both acute and chronic exposures. Arsine gas combines with haemoglobin in erythrocytes to produce severe haemolysis with anaemia, haemoglobinuria and haematuria. Subsequent jaundice may be severe. Signs and symptoms of toxicity include nausea, vomiting and diarrhoea, apprehension and malaise, tachycardia and dyspnoea. Acute renal failure is frequent and often fatal.

Acute poisoning by arsenic compounds other than arsine gas rarely occurs in industry, but has been reported to have occurred as a result of inhalation and percutaneous absorption, as well as from ingestion.

Exposure by oral ingestion to toxic doses of arsenic salts leads within one to two hours to acute gastrointestinal symptoms of vomiting and severe abdominal pain. Cardiovascular effects progress through vasodilation, cardiac depression then shock. The CNS effects are headache, coma, convulsions, and cerebral oedema. Sensory loss in the peripheral nervous system and motor dysfunction can occur one to two weeks after large exposures. Anaemia and leucopenia occur a few days following exposure. Arsenic intoxication may also result in hepatic toxicity, including toxic hepatitis and elevated liver enzyme levels. Arsenic can cause convulsions, coma and death in severe poisoning.

If inhaled, mucous membrane irritation, dyspnoea and pulmonary oedema may occur.

15. Chronic effects

- contact dermatitis, scaling, blistering of the skin, hyperpigmentation and hyperkeratotic lesions on the skin
- in the presence of sweat, skin abrasions, chafing or wounds, arsenic readily promotes ulceration of the skin
- conjunctivitis
- mucous membrane irritation and perforation of the nasal septum
- weakness, loss of appetite, gastro-intestinal disturbances
- liver cirrhosis and portal hypertension. There may also be an increased risk of liver cancer
- peripheral neuropathy initially of hands and feet; essentially sensory. In more severe cases, motor paralysis may occur
- peripheral vascular insufficiency has been observed in people with chronic exposure to arsenic in drinking water
- bone marrow depression with pancytopenia. Anaemia and leucopenia are common in chronic arsenic toxicity, and are often accompanied by thrombocytopenia and mild eosinophilia.

16. Carcinogenicity

Basal cell carcinomas, squamous cell carcinomas, Bowen's disease of the skin and lung carcinomas have been associated with chronic arsenic exposure. Skin cancers have been observed most commonly following exposure to medications containing trivalent arsenic compounds, particularly Fowler's solution, and environmental exposure to arsenic through drinking water.

Arsenic-induced skin cancer is frequently characterised by lesions over the entire body, mostly in unexposed areas like the trunk, palms and soles. Skin lesions manifest after a latent period of three to seven years for pigmentation changes and keratoses and up to 40 years for skin cancer.

A number of studies have shown an association between lung cancer and exposure to inorganic arsenic with the consistency between studies and biological gradient arguing for a causal relationship. There is a suggestion of an increased risk of liver, kidney and bladder cancer in some studies.

Work-related exposure to inorganic arsenic, especially in mining, copper smelting and pesticide work, has been associated with an increased risk of cancer.

17. Carcinogen and reproductive toxicant classifications¹

Arsenic acid and its salts with the exception of those specified elsewhere in Annex VI, arsenic trioxide, arsenic pentoxide and triethyl arsenate are classified according to the GHS as Carcinogenicity Category 1A (May cause cancer).

Lead hydrogen arsenate is classified as Carcinogenicity Category 1A (May cause cancer) and Reproductive Toxicity Category 1A (May damage the unborn child, suspected of damaging fertility).

■ 1 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 Arsenic*, Agency for Toxic Substances and Disease Registry, United States Department of Health and Human Services, Public Health Service, Atlanta, 2007.

International Agency for Research on Cancer, *Overall Evaluations of Carcinogenicity: An Updating of IARC Monographs Volumes 1-42*, Supplement No. 7, International Agency for Research on Cancer, Lyon, 1987.

Lauwerys RR, Hoet P, *Industrial Chemical Exposure Guidelines for Biological Monitoring*, 3rd Ed, Lewis Publishers, Boca Raton, 2001.

World Health Organisation/International Program on Chemical Safety. *Environmental Health Criteria 224: Arsenic and Arsenic Compounds*, World Health Organization, Geneva, 2001.

HEALTH MONITORING REPORT ARSENIC (INORGANIC)

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 ARSENIC RISK WORK (✓) all relevant boxes			
1. <input type="checkbox"/> New to arsenic (inorganic) work			
2. <input type="checkbox"/> New worker but not new to arsenic (inorganic) work			
3. <input type="checkbox"/> Current worker continuing in arsenic (inorganic) work			
4. Worked with arsenic (inorganic) 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

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5. WORK ENVIRONMENT ASSESSMENT		(✓) all relevant boxes
Date of assessment: DD/MM/YYYY		
Arsenic (Inorganic) Industry		
<input type="checkbox"/> Manufacture <input type="checkbox"/> Pesticides/Insecticides/ Fungicides <input type="checkbox"/> Leather Industry <input type="checkbox"/> Gold Smelting <input type="checkbox"/> Nickel Smelting <input type="checkbox"/> Tin Smelting <input type="checkbox"/> Other Metal Industry <input type="checkbox"/> Other (specify):	Controls: Wear gloves <input type="checkbox"/> Yes <input type="checkbox"/> No Respirator use <input type="checkbox"/> Yes <input type="checkbox"/> No Local exhaust ventilation <input type="checkbox"/> Yes <input type="checkbox"/> No Overalls / work clothing <input type="checkbox"/> Yes <input type="checkbox"/> No Laundering by employer <input type="checkbox"/> Yes <input type="checkbox"/> No Wash basins & showers (with hot & cold water) <input type="checkbox"/> Yes <input type="checkbox"/> No 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		
Has worker abstained from consuming seafood and red wine for three days or seaweed for four days before urine test? <input type="checkbox"/> Yes <input type="checkbox"/> No		
7. RECOMMENDATIONS (by Medical Practitioner)		(✓) all relevant boxes
1. <input type="checkbox"/> Suitable for work with arsenic (inorganic)		
2. <input type="checkbox"/> Counselling required		
3. <input type="checkbox"/> Review workplace controls		

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4. <input type="checkbox"/> Repeat health assessment in _____ month(s) / _____ week(s)		
5. <input type="checkbox"/> Removal from work with arsenic (inorganic)		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:

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SECTION 2 - 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"/> Female	<input type="checkbox"/> Male
<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
Numbness in hands or feet		<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:	