Changes in Permissible Exposure Levels of Toxic Substances and Medical Examination Requirements for Factory Workers exposed to Health Hazards Effected on 1 November 2004

To safeguard the health of workers, Permissible Exposure Levels (PELs) of toxic substances which should not be exceeded, are specified. Pre-employment and periodic medical examinations conducted by designated factory doctors are also required for workers exposed to prescribed hazards to monitor their health. The PELs and medical examination requirements have been reviewed to ensure they remain effective in safeguarding the health of our workers.

1. Changes in PEL

The PEL for asbestos has been specified and the PELs for benzene, cadmium and manganese have been reduced. The new PELs are specified in the Factories (Permissible Exposure Levels of Toxic Substances) Notification.

Substance	Old PEL	New PEL
Asbestos (all forms)	-	0.1 fibre/cc
Benzene	5 ppm	1 ppm
Cadmium (Elemental) (Compound)	 0.05 mg/m^3 0.05 mg/m^3	 0.01 mg/m^3 0.002 mg/m^3
Manganese (Dust)	5 mg/m^3	1mg/m^3

2. Changes in Medical Examination Requirements

a. New Urine Test for Benzene Exposed Workers

Workers exposed to benzene will be required to have their urine tested for tt-muconic acid or s-phenylmercapturic acid instead of phenol at the preemployment and annual medical examinations. The new tests are more sensitive and specific and are more suitable for monitoring low benzene exposure. These changes are made under the Factories (Medical Examinations) (Amendment) Regulations.

b. New Biological Threshold Limit Values (BTLV) for benzene and cadmium

Hazard	Test	Old BTLV	New BTLV*
Benzene	Urine tt-muconic acide	-	1.6 mg/g cr**
	Urine s-phenylmercapturic acid	-	45 ug/g cr
Cadmium	Blood cadmium	10 ug/l	5 ug/l
	Urine cadmium	10 ug/g cr	5 ug/g cr

* BTLV is the level above which the worker is considered to have excessive absorption of the substance and require suspension from further exposure

** creatinine (urine samples are corrected for creatinine)

Designated Factory Doctors may refer to Annex A to know more about the changes in the medical examinations for benzene and cadmium.

If you need further clarifications please email to: mom_oshd@mom.gov.sg

BENZENE

TOXIC EFFECTS

Acute poisoning

(a) Narcosis
(b) Skin and mucous membrane irritation

Chronic poisoning

(a) Non-specific manifestations eg anorexia, headache, dizziness

(b) Bone marrow depression

- leucopenia, thrombocytopenia, anaemia, pancytopaenia
- aplastic anaemia

(c) Skin irritation (repeated skin contact)

- dry, scaly dermatitis
- erythema and/or blistering

Others

(a) Leukaemia (most common being acute myeloid leukaemia)
(b) Lymphoma
(c) Multiple myeloma

MAIN INDUSTRIES AND OCCUPATIONS AT RISK

(a) Petrochemical industries eg manufacture of benzene, production of carbon black
(b) Petroleum refineries
(c) Petrol retailers eg oil terminals (loading and unloading) and service stations
(d) Manufacture of plastics, synthetic fibres, detergents, synthetic resins, butadiene rubber, styrene, phenol
(e) Laboratories eg use of benzene in analytical techniques
(f) Work involving use of commercial solvents such as toluene and xylene (Benzene may be present as a contaminant)
(g) Work involving handling of fuels containing benzene eg vehicle workshops

MEDICAL EXAMINATIONS

Indications

Any occupational exposure to benzene

Types of Tests and Frequency of Examinations

(a) Pre-employment and Annual

- Clinical examination with particular emphasis on the haematological and central nervous systems
- Haemoglobin and full blood count (total white blood cells, red blood cells and platelets)
- Peripheral blood film (to look for blast cells)
- Urinary tt-muconic acid (tt-ma) or s-phenylmercapturic acid (s-pma) estimation in an end-of-the-shift urine sample taken mid-week (Creatinine-corrected). (Inhalation of tobacco smoke increases background levels and this should be considered in the interpretation of the results).

(b) Where indicated, bone marrow biopsy may be done

INDICATIONS FOR SUSPENSION FROM EXPOSURE AND NOTIFICATION TO CIF

(a) All cases of definite or suspected poisoning and excessive absorption

(b) Cases with urine tt-ma levels of more than 1.6 mg/g Cr or urine s-pma levels of more than 45 ug/g Cr in 2 successive examinations

(c) Cases of anaemia and/or leukaemia (note: Each laboratory has its own "normal range" for haemoglobin. The lower limit of this range, subject to a margin of error of up to 5%, depending on the laboratory, may be taken, as the level for the diagnosis of anaemia). All cases recommended for suspension and suspected cases of benzene poisoning/excessive absorption or cancer must be notified to the Chief Inspector of Factories, c/o Occupational Health Department.

FOLLOW-UP ACTION

Repeat tests

(a) Abnormal results

- If the urine tt-ma level is 1.6 mg/g Cr or more or the urine s-pma level is 45 ug/g Cr or more, repeat test immediately.

- An abnormal blood count and/or peripheral blood film should be investigated to exclude effects due to benzene even if the urine tt-ma level is below 1.6 mg/g Cr or the urine s-pma level is below 45 ug/g Cr.

- Workers with rising urine tt-ma or s-pma levels and/or significant changes in blood counts should be investigated.

(b) Suspended cases

- All suspended cases should have repeat urine phenol estimations at monthly intervals. The worker may return to work with benzene when the urine tt-ma level falls below 1.6 mg/g Cr or the urine s-pma level falls below 45 ug/g Cr and haematological results are normal.

OTHER SPECIFIC CONTROL MEASURES

(a) Young persons under 18 years of age and pregnant/nursing mothers should not be exposed to benzene.

(b) Workers with liver disease and/or anaemia should not work in areas where there is significant benzene exposure.

USEFUL REFERENCES

1 Threshold Limit Values (for Chemical Substances and Physical Agents) and Biological Exposure Indices, American Conference of Government Industrial Hygienists (ACGIH), Cincinnati, Ohio, USA, 2004.

2 American Conference of Government Industrial Hygienists (ACGIH): Benzene. In: Documentation of Threshold Limit Values and Biological Exposure Indices, 7th ed. ACGIH, Cincinnati, Ohio, USA, 2001.

3 Boogaard PJ, van Sittert NJ: Biological monitoring of Exposure to Benzene: A comparison between s-phenylmercapturic acid, trans, trans-muconic acid, and phenol. Occup. Environ. Med. 52: 611-620, 1995.

4 Ong CN, Kok PW, Ong HY et al: Biomarkers of Exposure to Low Concentrations of Benzene: A Field Assessment. Occup. Environ.Med. 53;328-333, 1996.

5 Austin H, Deizell E, Cole P: Benzene and Leukemia. A Review of the Literature and a Risk Assessment. Am. J. Epidemiol. 127;419-439, 1988

6 Swaen GMH, Meijers JMM: Risk Assessment of Leukemia and Occupational Exposure to Benzene. Br J Ind. Med. 46;826-830, 1989

7 Paxton MB, Chinchilli VM, Brett SM et al: Leukemia Risk Associated with Benzene Exposure in the Pliofilm Cohort: II. Risk Estimates, Risk Anal. 14;155-161, 1994

CADMIUM AND ITS COMPOUNDS

TOXIC EFFECTS

Cadmium Poisoning

(a) Acute Poisoning

- Chemical pneumonitis following fume inhalation; onset within 8 to 24 hours; mortality 15%
- Gastrointestinal tract irritation following accidental ingestion.

(b) Chronic Poisoning

- Renal dysfunction (tubular and/or glomerular damage with low molecular weight proteinuria, glucosuria, amino aciduria, albuminuria and reduced creatinine clearance).
- Emphysema
- Bone pain; osteomalacia & fractures
- Anosmia

Note:

- Cigarette smoking adds to cadmium burden. Each cigarette contains about 1 - 2 ug cadmium (Cd) of which approximately 25 -50% is retained in the lungs.

- The average normal gastrointestinal absorption in man ranges from 3 -7% of ingested cadmium. This increases to as high as 20% with nutritional deficiencies of calcium, iron or protein.

MAIN INDUSTRIES AND OCCUPATIONS AT RISK

(a) Nickel-cadmium battery manufacturing (tabletting and assembly of Cd electrodes)

(b) Silver brazing, welding and soldering operations using cadmium-containing fillers. (Note: The import and use of cadmium-containing silver alloys for brazing is under licensing control by NEA in view of the serious hazard posed if the process is carried out without adequate control measures)

(c) Plastics industry, especially compounding of polyvinly chloride (PVC); used as thermal stabiliser

(d) Electroplating

(e) Pigment manufacture and use, eg. for plastics, textile, paper, rubber industries; in inks, enamels & glazes

(f) Alloy manufacture, eg low melting-point brazing alloys, Ag-Cd & Cu-Cd

(g) Fungicides manufacture and use

(h) Manufacture of refrigerators, air-conditioners, television picture tubes, semiconductors, photo-cells & fluorescent lamps, and as neutron absorber in nuclear reactors.

(i) Jewellery manufacture

(j) Automobile and aircraft industries

(k) Smelting and refining of Zn, Pb or Cu ores and scrap processing

(l) Industrial waste treatment plants

MEDICAL EXAMINATIONS

Indications:

Any work where workers are exposed to levels of airborne cadmium which are liable to be in exceed 10% of the permissible exposure level and/or where there is significant risk of ingesting cadmium.

Types of Tests and Frequency of Examinations:

(a) Pre-employment and Annual:

- Clinical examination with particular emphasis on the olfactory sense, renal, respiratory and skeletal system.

- Blood cadmium estimation (venous blood in heparinised container)

- Urine $Beta_2$ - microglobulin estimation. DO NOT USE EARLY MORNING SPECIMEN. Collect morning specimen 2 hours after drinking 15 ml. Mist Potassium Citrate. Discard specimen if urine pH lower than 5.6. Keep specimen refrigerated after collection and in ice during transportation. Specimens should reach the laboratory within 2 hours after collection.

(b) Where indicated, the following tests may be done:

- Urine cadmium estimation (early morning specimen collected in acid-washed container and corrected to SG of 1.016 or creatinine concentration)

- Urine examination for total protein using the Trichloroacetic acid (TCA) test (To 1 ml urine add 100ul 25% TCA. Mix and read turbidity against protein standards of 10 mg - 100 mg/dl); early morning specimen.

- Urine examination for albumin and transferrin, glucose, calcium, phosphates and amino acids and microscopic examination; urine protein electrophoresis.

- Full-size chest x-ray and lung function tests (FEV_1 and FVC)

- Abdominal X-ray (for renal stones) and X-rays of long bones, scapula and pelvis (for osteomalacia and fractures)

- Haemoglobin estimation

- Blood pressure measurement

- Serum creatinine and urea estimation

- Creatinine clearance estimation

INDICATIONS FOR SUSPENSION FROM EXPOSURE AND NOTIFICATION TO CIF

(a) All cases of definite or suspected cadmium poisoning and excessive absorption.

(b) All cases of renal dysfunction (tubular or glomerular)

(c) All cases with abnormal lung function

(d) Cases with blood cadmium levels of more than 5 mcg/litre in 2 successive examinations.

(e) Cases with urine cadmium levels of more than 5 mcg/gm creatinine in 2 successive examinations.

(f) Cases with urine $Beta_2$-microglobulin exceeding 290 mcg/litre or mcg/gm Cr. in 2 successive examinations.

(g) All cases with evidence of cancer (lungs)

All cases recommended for suspension and suspected cases of cadmium poisoning/excessive absorption or cancer must be notified to the Chief Inspector of Factories (c/o Occupational Health Department).

FOLLOW-UP ACTION

Repeat tests

(a) Abnormal results

- If the blood cadmium level exceeds 5 mcg/litre, a repeat blood cadmium test must be done immediately together with a urine cadmium estimation and creatinine clearance test.

- If the urine $Beta_2$-microglobulin result exceeds 290 mcg/gm creatinine, a repeat test should be done one month later.

(b) Suspended cases:

- All suspended cases should have repeat blood and/or urine cadmium and/or urine $Beta_2$-microglobulin examinations, where indicated, at 3-monthly intervals. They should not return to cadmium work until the blood and/or urine cadmium level and urine $Beta_2$-microglobulin concentration fall below 5 mcg/litre, 5 mcg/gm creatinine and 290 mcg/gm creatinine respectively, and symptoms, if any, have disappeared.

- Cases with definite evidence of permanent renal or lung damage or cancer should preferably not continue with cadmium work.

Treatment

All cases of cadmium poisoning must be immediately removed from exposure. Acute poisoning cases must be referred for hospital treatment. There is no suitable antidote.

USEFUL REFERENCES

1 American Conference of Government Industrial Hygienists: Threshold Limit Values (for Chemical Substances and Physical Agents) and Biological Exposure Indices, ACGIH, Cincinnati, Ohio, USA, 2004

2 American Conference of Government Industrial Hygienists: Cadmium. In: Documentation of Threshold Limit Values and Biological Exposure Indices, 7th ed. ACGIH, Cincinnati, Ohio, USA, 2001.

3 Mason HJ, Davison AG, Wright AL et al: Relations between Liver Cadmium, Cumulative Exposure, and Renal Function in Cadmium Alloy Workers. Br. J. Ind. Med. 45;793-802, 1988.

4 Chia KS, Ong CN, Endo G: Renal Tubular Function of Workers Exposed to Low Levels of Cadmium. Br. J. Ind. Med. 46;165-170, 1989.

5 Bernard AM, Roels H, Cardenas A, Lauwerys R: Assessment of Urinary Protein 1 and Transferrin as Early markers of Cadmium Nephrotoxicity. Br. J. Ind. Med. 47;559-565, 1990.

6 World Health Organisation: Recommended Health Based Limits in Occupational exposure to heavy metals - Report of a WHO Study Group, Technical Report Series 647, 1981.

7 Cadmium and Health: A Toxicological and Epidemiological Appraisal Vol I and II. 1985.