NSW | WorkCover

Chemical analysis branch handbook

9th edition

Workplace and biological monitoring exposure analysis

Contents

General information

The Chemical Analysis Branch is located at Thornleigh in the northern suburbs of Sydney. It is a specialised occupational health analytical service focusing on the presence of hazardous substances in the workplace and is National Association of Testing Authorities, Australia (NATA) accredited to ISO/IEC 17025. The branch is part of TestSafe Australia which is owned by WorkCover NSW.

Tests are performed on biological (blood or urine) and workplace (air, dust, vapour, solid or liquid) samples as part of worker and workplace assessments. The main areas of analysis cover exposure to pesticides, metals, elements, solvents, organic vapours, dusts, and various inorganic and organic substances including carcinogenic substances.

The laboratory utilises state of the art modern instrumental techniques which include gas chromatography, mass spectrometry, liquid chromatography, x-ray diffractometry/fluorescence spectrometry, atomic absorption, inductively coupled plasma mass spectrometry, infrared spectrophotometry and microscopy.

Laboratory staff are specialists in the above areas and have NATA signatory status.

The laboratory's NATA accreditation number is 3726. For more information about the scope of accreditation, visit nata.com.au

For technical enquiries or administrative assistance, call **61 2 9473 4000** or email lab@workcover.nsw.gov.au

Workplace monitoring

Table 1 lists the routine occupational hygiene tests that are available for workplace assessments. The types of samples or sampling devices are specified along with recommended sampling conditions or requirements. It is also recommended that field blanks(s) or control(s) be submitted with samples when requesting tests from the laboratory. Information is also supplied about the analytical methods used. Wherever possible, in-house methods are based on those of NIOSH, OHSA, HSE and Australian Standards. Results are reported in terms of an amount found in the sample or sampling device.

The laboratory also performs many non-routine tests which are not listed in table 1. For many of these requests, the acquisition of analytical reference standards is all that is required for the laboratory to be able to validate modified or new test procedures. Where methods do not exist, the laboratory can often develop a new procedure to allow the test to be performed however this approach may take several weeks or months.

For assistance contacting consulting occupational hygienists who are members of the Australian Institute of Occupational Hygienists, call **61 2 9473 4000** or visit aioh.org.au

Between collection and transport

Between collection and transport to the laboratory, samples for organic requests should always be kept cool to maintain sample integrity. An ice-brick is recommended to accompany the specimens during transportation. Samples should be transported as soon as possible after collection. If this is not possible, store samples in the fridge until transport can be arranged.

Biological monitoring

Table 2 lists the blood and urine tests available from the laboratory.

Collection of urine specimens

Prior to collection, workers are encouraged to change out of their work clothes and thoroughly wash their hands to avoid possible contamination when collecting the urine specimen. Showering prior to collection is even better.

Urine specimens (except 24-hour urines) should be midstream. The collection of urine specimens may appear to be an easy alternative to collecting blood specimens. However, it is often difficult to obtain a urine specimen that is not contaminated or a specimen that is not too diluted or too concentrated. Also care must be taken to ensure that the worker does not have significant renal impairment. In the past, 24 hour specimens were routinely collected for many analyses in order to average out the fluctuations in urine concentration that often occur. Because of the difficulty in achieving worker compliance with this form of urine collection, an attempt has been made to use spot urine specimens for routine urine analyses. Correction of the urinary analyte to either a standard specific gravity, a standard urinary volume rate or to the creatinine content have now been advocated in an attempt to compensate for fluctuations in urinary concentration. Currently the laboratory policy is to report urinary analyses in terms of the creatinine concentration of the urine. This form of correction is not effective for all substances eliminated from the body in the urine – eg toluene, styrene or fluoride. At present the policy is to align the laboratory's creatinine correction procedures with the American Conference of Governmental Industrial Hygienists (ACGIH). This organisation is currently reviewing their creatinine correction policy and the laboratory will await further developments before making any changes to the current procedure.

It is recommended that if a collected urine specimen is obviously either too diluted or too concentrated, arrangements should be made for recollection rather than submit it for analysis. The ACGIH recommends rejection of urine specimens with creatinine concentrations greater than or equal to 3g/L or less than or equal to 0.3g/L. To convert a creatinine corrected result to an uncorrected result, multiply the corrected result by the creatinine result – eg a 50μg analyte/g creatinine result for a urine specimen with 2g creatinine/L of urine converts to 100μg analyte/L of urine.

The biological half-life of a substance should also be taken into consideration when arranging the timing of collection of specimens and when interpreting results, particularly when the substance is eliminated rapidly.

'End of shift'

'End of shift' collections should be the first lot of urine voided after the work shift. Collection should take place in the last two hours of exposure or immediately after the shift has ended.

'End of shift at end of workweek' or 'End of workweek'

'End of shift at end of workweek' or 'End of workweek' sampling times imply a continuous exposure of the worker to the chemical substance throughout the entire working week. If the worker is exposed on only one occasion during a working week, the sampling time then should be at the end of shift/exposure.

Between collection and transport

Between collection and transport to the laboratory, specimens should always be kept cool to maintain specimen integrity. An ice-brick is recommended to accompany the specimens during transportation. Specimens should be transported as soon as possible after collection.

Baseline or background analyses

These are analyses performed to determine a person's exposure level of a chemical in their blood or urine. The subsequent results are compared against this result to determine the net increase in absorption of the chemical due to occupational exposure.

Biological half-life

Biological half-life (T(½)) refers to the length of time it takes the body to rid itself of half the amount of a chemical it has absorbed – eg absorbing 40 μmol of a chemical having a T(½) of three days:

- after three days 20 μmol will remain in the body
- after six days 10 μmol will remain in the body
- after nine days 5 μmol will remain in the body.

For best interpretation of analytical results performed on a routine specimen, the collection time for that specimen should be within one half-life from the end of the chemical exposure. Biological half-lives are reflected in the given sampling times.

Biological Occupational Exposure Limit (BOELS)

BOELs are reference values intended as guidelines for evaluating potential health hazards. Table 2 lists the blood and urine tests available from the laboratory and a compilation of BOELs. These limits have been adopted by WorkCover. The source of the BOEL adopted is stated in table 2 (see 'reference' column). In most cases the laboratory is aligned with the American Conference of Governmental Industrial Hygienists (ACGIH) which has adopted biological exposure indices (BEIs).

Confidentiality

The branch ensures confidentiality between the laboratory and the customer. No information shall be passed onto any person within TestSafe Australia, WorkCover NSW or to corporate entities or other individuals.

Table 1 – Workplace monitoring analysis

Substance	Sample	Sample requirements	LOQ	Exposure	Method	Comments
Acid screen Hydrobromic acid Hydrochloric acid Hydrofluoric acid Nitric acid Oxalic acid Phosphoric acid Sulfuric acid	Air/silica gel tube (SKC-226-10-03) [25mm cellulose acetate membrane filter (0.8μm) can also be used for sulfuric acid]	0.2–0.5L/min for tubes. Min. Vol.3L Max. Vol.100L Blanks required [1.5L/min for filters with a recommended sample size of 180L]	2.5μg/tube or filter	 9.9mg/m^3 (TWA) 7.5mg/m^3 (TWA) 2.6mg/m^3 (TWA) 5.2mg/m^3 (TWA) 1mg/m^3 (TWA) 1mg/m^3 (TWA) 1mg/m^3 (TWA)	NIOSH 7903 (Modified), IC WCA194 (Screen) WCA109 (H_2SO_4)	Samples are desorbed with deionised water and the inorganic anions are analysed by HPLC using conductivity detection. Results are reported as the corresponding acid.
Acetic acid	Coconut shell charcoal sorbent tube (SKC226-01)	Flow rate: 0.2L/min Vol: 240min	2.0μg/tube	10ppm (TWA) 15ppm (STEL)	OSHA PV2119, IC WCA 208	Samples are extracted with 0.01 N NaOH and analysed by IC using a conductivity detector.
Aldehyde screen Acetaldehyde Acrolein Chloroacetaldehyde Crotonaldehyde Formaldehyde n-Valeraldehyde	Air/glass fibre filter impregnated with 2,4-Dinitrophenylhydrazine Passive sampling can be undertaken using UMEx-100 sampling devices.	0.5L/min. Two thick 37mm filters in air monitoring cassette. Keep cool and covered in foil when not sampling. Min. Vol.15L, Max. Vol. 60L Blank filter required. Contact laboratory for filters.	0.25μg/filter 0.25μg/filter 0.25μg/filter 0.25μg/filter 0.25μg/filter 0.25μg/filter	 36mg/m^3 (TWA) (20ppm) 0.23mg/m^3 (TWA) (0.1ppm) 3.2mg/m^3 (TWA) (1ppm) 5.7mg/m^3 (TWA) (2ppm) 1.2mg/m^3 (TWA) (1ppm) 176mg/m^3 (TWA) (50ppm)	OSHA Method 64 (modified), LC WCA 179	Filters are desorbed with acetonitrile and the DNPH derivative is analysed by HPLC at 365 nm.
Acrylic acid	Air/XAD-8 silica bead sorbent tube (SKC-226-30-08). Sample section 100mg. Two tubes are used in line.	0.1L/min Min. Vol.1.5L Recommended Vol.24L	1μg/tube	5.9mg/m^3 (TWA) (2ppm)	OSHA Vol. 1 Method 28, LC WCA 157	Tube is desorbed with a methanol/ water solution and analysed using UV detection at 210nm.

Table 1 – Workplace monitoring analysis

Substance	Sample	Sample requirements	LOQ	Exposure	Method	Comments
Alkaline dust NaOH, KOH, LiOH and other basic salts as dust or mist	Filter, 1μm PTFE 37mm membrane (eg Zefluor from Gelman Sciences or equivalent)	Flow rate between 1 and 4L/min for a sample size of 70 to 1000L. Do not exceed a filter loading of about 2mg total dust	0.03mg/sample (as NaOH) (7 x 10-4 moles of alkalinity)	2mg/m^3 (NaOH) (Ceiling)	NIOSH Method 7401, (Issue 2), TR WCA 177	The method measures total alkalinity of alkali hydroxides, carbonates, borates, silicates, phosphates, and other basic salts, expressed as equivalents of sodium hydroxide.
Amines in air (aliphatic) Iso-propylamine Propylamine Sec-Butylamine n-Butylamine Hexylamine Cyclohexylamine Dimethylamine Diethylamine Dipropylamine Dibutylamine Dimethylethylamine Trimethylamine Triethylamine Tributylamine Tert-Butylamine	Air/silica gel tube (SKC-226-10)	0.01 to 1.0L/min Total volume of 3 to 30L	0.01mg/tube	Methylamine 13mg/m^3 (TWA) (10ppm) n-Butylamine 15mg/m^3 (TWA) (5ppm) Diethylamine 30mg/m^3 (TWA) (10ppm) Trimethylamine 24mg/m^3 (TWA) (10ppm) Triethylamine 12mg/m^3 (TWA) (3ppm)	NIOSH method 2010 (modified) GCMS WCA 180	Tube is desorbed with an acidified methanol solution. Alkali is added and the free volatile amines are analysed by headspace GCMS.
Ammonia	Air/silica gel tube (SKC-226-10-06)	0.1 to 0.5L/min. 96L max volume.	1μg/tube	17mg/m^3 (25ppm) TWA	NIOSH method 6016 (modified), IC WCA 149	Tube is desorbed with water and analysed by HPLC with conductivity detection.
Asbestos	Bulk samples (eg fibro, lagging, dusts)	5–10g or a 50 x 50mm piece	Trace	N/A	AS4964-2004 PLM/DS WCA 201	Chrysotile, amosite and crocidolite in bulk samples determined by polarised light microscopy including dispersion staining. Qualitative determination only.
Atrazine	Air/GF filter	0.5L/min	0.3μg/sample	5mg/m^3	Vermeulen et al J. Chromat. 1982, 240 (1) 247-253, LC WCA 167	

Table 1 – Workplace monitoring analysis

Substance	Sample	Sample requirements	LOQ	Exposure	Method	Comments
Cristobalite α-quartz + cristobalite reported	Respirable dust Air/25 mm PVC membrane filter GLA5000 (pall corporation) or equivalent, 5μm	Respirable dust (AS 2985-2004)	0.01mg/filter	0.1mg/m^3 (TWA)	NHMRC method for measurement of α-quartz in airborne dust by FTIR and XRD (1984), XRD WCA 220	Non-destructive technique. Amorphous (non-crystalline) forms of silica not detected. Free silica polymorphs (α-quartz, cristobalite and tridymite) resolved.
Cytotoxic drugs Cyclophosphamide Ifosfamide Doxorubicin Vincristine Etoposide Methotrexate	Swab – Isopropanol Wipe a known area of the surface (eg 10 x 10cm)		3ng/sample (equivalent to 0.03ng/cm^2 when 10 x 10cm sampled)		LCMS WCA 233	Swab is treated with 0.03M NaOH and then extracted with ethyl acetate and analysed by UPLC/MSMS ESI+.
Drugs	Air/25 mm glass fibre filter	1L/min	Enquire at Lab	Enquire at Lab	In House Method LC	Drugs are desorbed from filters in organic/aqueous solutions and analysed by HPLC.
Dust	Membrane Filter	2 blank filters must be supplied	0.01mg/filter LOQ 0.001mg/filter LOD	10mg/m^3 (TWA) measured as inhalable dust	AS3640 – 1989 GRAV WCA 151	For pre and post weighing of filters.
16 Elements As, Cd, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, Se, Sn, Ti, V, W, Zn	Inhalable dust Air/25 mm PVC membrane filter GLA 5000 (Pall Corporation) or equivalent, 5μm 2L/min Welding Fumes Air/25 mm membrane filter DM 800 (Gelman Sciences) or equivalent. Any PVC filter that complies with ASTM D 2986-71 ie, DOP 0.3μm at 32L/min 99.94%	Inhalable dust (AS 3640-2004) 2L/min Welding Fumes (AS3853.1-1991)	1μg/filter 1μg/filter	Enquire at Lab Total Inhalable Dust 10mg/m^3	XRF WCA 181 XRF WCA 182	Membrane filters are analysed directly by x-ray fluorescence spectrometry which is a non-destructive technique. See also, Hurst J and Geyer R, 12th Annual AIOH Conference 1993. (Modified HSE MDHS 91) North, M.R.,and Haswell, S.J. J Anal. At.Spec 1988.
Elements on surfaces Be, V, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Sr, Cd, In, Sn, Sb, Pt, Hg, Tl, Pb, Bi, U	Surface/swab Ghost wipe preferred swab	Swab a surface area usually of 10 x 10cm	5μg/sample (1μg/sample Be)		WCA.219	A surface sample is taken of known area. The sample is digested with nitric acid and analysed by ICPMS.

Table 1 – Workplace monitoring analysis

Substance	Sample	Sample requirements	LOQ	Exposure	Method	Comments
50 Elements Al, Sb, As, Ba, Bi, Br, Cd, Cs, Ca, Cl, Cr, Co, Cu, Ga, Ge, Au, Hf, In, I, Ir, Fe, Pb, Mg, Mn, Hg, Ni, Nb, Pd, P, Pt, K, Rh, Rb, Se, Si, Ag, Na, Sr, S, Tl, Te, Ta,Sn, Ti, W, U, V, Y, Zn, Zr	Bulk solids (eg soil, powders)	10g preferably less than 2mm aggregate	0.01% w/w	N/A	In House Method XRF WCA 113	Samples analysed as pressed powders using Uniquant software.
Ethylenediamine (EDA) Diethylenetriamine (DETA) Triethylenetetramine (TETA)	XAD-2 (SKC 226-30-18)	Flow rate: 0.01 to 0.1L/ Min. Vol: 1L – 20L	3.0µg/tube EDA 0.1µg/tube DETA 0.2µg/tube TETA	10ppm (TWA) for EDA 1ppm (TWA) for DETA 2ppm (TWA) for TETA	OSHA 60 NIOSH 2540 LC WCA 222	Samples are collected on XAD-2 resin coated with 10% 1-naphthylisothiocyanate (NITC). Samples are desorbed with dimethylformamide, and the amine derivative is analysed by HPLC using UV detection at 254 nm.
Ethylene oxide	3M Monitor (3550-3551)	Passive monitor suitable for 15 mins sample or 8 hrs	0.5µg/sample (0.4ppm for 15 min or 0.01ppm for 8 hours)	1ppm (TWA)	3M (Ethylene Oxide) GCMS WCA 217	EO is absorbed on charcoal that has been chemically treated with HBr. The vapours are converted to 2-bromoethanol, desorbed with 10% methylene chloride in methanol and quantitated using a GC/ MS in SIM mode.
Ethanolamine (MEA) Diethanolamine (DEA) Triethanolamine (TEA)	Silica gel sorbent tube (SKC 226-10)	Flow rate: 0.1 to 0.2L/min Vol: 4 – 24L	1.0µg/tube MEA 2.0µg/tube DEA 3.0µg/tube TEA	3ppm (TWA) and 6ppm (STEL) for MEA 3ppm (TWA) for DEA	NIOSH 2007 NIOSH 3509 (modified) IC WCA 228	Samples are collected on silica gel tubes (SKC 226-10), extracted with 1.7 mM HNO3 and analysed by Ion Chromatography (IC) using a conductivity detector.
Filter weight	Membrane filter	Contact laboratory for pre-weighing of filters.	0.01mg/filter		AS3640 – 1989 GRAV WCA 156	For single weighing of filter.

Table 1 – Workplace monitoring analysis

Substance	Sample	Sample requirements	LOQ	Exposure	Method	Comments
Fluoride	Air/cellulose acetate membrane filter (0.8 mm) with Na_2CO_3 treated cellulose backing pad	1–2L/min Min.Vol. 12L, Max.Vol. 800L Blank filter required. Contact laboratory for filters.	3µg F/sample filter	2.5mg/m^3 (TWA)	NIOSH 7902 modified ISE WCA 117	Measurement using ion specific electrode. Method measures soluble particulate and gaseous forms of fluoride.
Formaldehyde	Air/Impinger solution containing aqueous sodium metabisulphite (20mls) 3M Passive Monitor (3721) (See also aldehyde screen)	0.2–1L/min Min. Vol. 1L; Max. Vol. 100L Blank solution required Contact laboratory for impinger solution. ½–1 whole workshift	1µg/impinger solution 0.2µg/passive monitor	1.2mg/m^3 (1ppm) TWA 1.2mg/m^3	NIOSH 3500 modified SPEC WCA 111 3M – Method SPEC WCA 111	Formaldehyde is trapped in the aqueous metabisulphite solution and then reacted with a chromotropic acid reagent to form a coloured complex which is measured at 575 nm. Formaldehyde vapour monitors are desorbed with water and this is then reacted with a chromotropic acid reagent to form a coloured complex which is measured at 575 nm.
Formaldehyde and/or glutaraldehyde	Air/glass fibre filter impregnated with 2,4-Dinitrophenylhydrazine Two 37mm filters in air monitoring cassette. Keep cool and covered in foil when not sampling. SKC tube SKC 226-119 UMEx 100 Passive sampler	0.5L/min for formaldehyde 1L/min for glutaraldehyde. Sample Vol. 15L for glutaraldehyde Peak Limitation, Max. Vol. 120L Blank filter required. Contact laboratory for filters. 0.03 – 0.5L/min Min:1L Max: 15L	0.25µg/filter	0.41mg/m^3 (0.1ppm) Peak Limitation	OSHA Method 64 modified LC WCA 114 NIOSH 2016	Filters are desorbed with acetonitrile and the DNPH derivative is analysed by HPLC at 365 nm. Sampling rates for UMEx-100 Formaldehyde: 28.6 mL/min and Glutaraldehyde: 14.3 mL/min

Table 1 – Workplace monitoring analysis

Substance	Sample	Sample requirements	LOQ	Exposure	Method	Comments
Glycols	XAD7-OVS tube 200mg/100 mg (SKC 226-57)	0.5 – 2L/min Min. Vol. 5L Max Vol. 60L Ship to lab in esky with ice-brick	25μg/tube	Ethylene glycol (vapour) 52mg/m^3 (20ppm) Propylene glycol (total vapour and particulates) 474mg/m^3 (10ppm) Diethylene glycol 100mg/m^3 (23ppm)	NIOSH 5523 GC WCA 209	XAD-7 OVS tube is desorbed with methanol and ultrasonication. The glycols are then analysed by dual column GC/FID.
Hexavalent chromium (Total)	Air/25 mm PVC membrane Filter (0.5μm)	Flow rate: 1–4L/min Use inhalable dust sampling head.	0.5μg/filter	0.05mg/m^3 TWA	AS 3853.1-2006 SPEC WCA 176	The test measures both water soluble and insoluble Chromium VI after initially screening for total chromium.
Hydrogen sulfide	Air/pre-filter (zefluor; 0.5μm 25mm) / charcoal tube (SKC 226-09)	Recommend flow rate: 0.2L/min Flow rate range: 0.1–1.5L/min Min. Vol. 1.2L Max Vol 40L Blank tube required	2.0μg/tube as H S 2	14mg/m^3 (TWA) (10ppm)	NIOSH 6013 (Modified) IC WCA 183	Charcoal tubes are desorbed with an ammonia/hydrogen peroxide solution which oxidises H2S to the sulfate anion. The sulfate is analysed by HPLC using conductivity detection.
Inhalable dust	Inhalable dust Air/25mm PVC membrane filter GLA 5000 (Pall Corporation) or equivalent, 5μm 2L/min	Inhalable dust (AS 3640-2004) 2L/min	0.01mg/Filter	Total inhalable dust 10mg/m^3	WCA 190	A gravimetric determination of both a pre-weight and a post-weight sample is performed. It is preferable for both weights to be performed in the same laboratory.

Table 1 – Workplace monitoring analysis

Substance	Sample	Sample requirements	LOQ	Exposure	Method	Comments
Isocyanates	Air/impinger solution containing methoxy phenyl piperazine (10mL) or glass fibre filters impregnated with methoxy phenyl piperazine.	Impinger solution to be kept in the dark as much as possible. 1L/min for 15min. Blank solution must be supplied with samples. A sample of the isocyanate(s) being used should be supplied to the laboratory. Contact laboratory for impinger solution or filters. Filter 2L/min for 15 min. For combined Impinger/ Filter sampling use a flow rate of1L/min.	0.1μg Total NCO / sample (This is equivalent to 0.001mg/m^3 NCO for a 15min sample at 1L/min flow rate)	0.02mg/m^3 (TWA) as NCO	HSE-MDHS 25/3 LC WCA 110	Analysis requires the detection by both UV and electrochemical detectors. This method measures total isocyanates (ie monomers and polymers) expressed as NCO groups. For isocyanates present as aerosols an impinger solution followed by a filter is the recommended sampling device. For vapours a filter sampler alone is sufficient.
Lead	Paint flakes	Minimum 100mg paint flakes	0.01% w/w	1% by weight of the dry paint AS4361.2 1998 Guide to Lead Paint Management: Part 2 Residential and Commercial Buildings 1988.	In-house method ICPMS WCA 213	Paint flakes are digested in nitric acid and then analysed using ICPMS.
Maleic anhydride	Air/15mL impinger solution containing 0.1% aqueous phosphoric acid	0.2–1.5 L/min Min. Vol. 40L, Max. Vol. 500L. Blank solution required.	7.5μg/sample	1mg/m^3 (0.25ppm) TWA	Modified NIOSH 3512, LC WCA 160	Absorbing solution is analysed by HPLC with detection of maleic anhydride at 254nm.
Mercury in air (elemental)	Solid sorbent tube For expected high loadings use SKC hopcalite Cat No. 226-17-3A (8 x 110mm – 500mg) For typical loadings use SKC hopcalite Cat No. 226-17-1A (6 x 70mm – 200mg)	0.15–0.25L/min Sample size 2 – 100L	0.1μg/tube	0.025mg/m^3	NIOSH 6009 CVAAS WCA 174	Elemental mercury is trapped on hopcalite tubes. Desorbed with nitric/hydrochloric acid solution. Analysis by cold vapour atomic absorption spectrophotometry. Inorganic and organic mercury compounds may cause a positive interference.

Table 1 – Workplace monitoring analysis

Substance	Sample	Sample requirements	LOQ	Exposure	Method	Comments
Methyl bromide	Air/anasorb 747 coconut charcoal tube (SKC 226-83 x 2in series) (8 x 110 mm – 400/200mg)	0.01 – 0.1L/min Min Vol. 1L, Max Vol. 5L (Use 1L sample volume if relative humidity is >50%) Pack in dry ice for shipment	0.5μg/sample	5ppm (19mg/m^3)	WCA 232	Two Anasorb 747 sampling tubes are used in series and are separated after sampling, capped separately. The samples are then shipped to the laboratory on dry ice. Analysis is performed by desorption with dichloromethane and analysed by GCMS in the SIM mode.
Minerals	Bulk solids (eg sands, powders)	5–10g preferably less than 2mm aggregate	1–10% w/w	N/A	In House Method XRD WCA 112	Screening test using ICDD Mineral Data Base. Samples analysed by x-ray powder diffractometry and must have crystalline phases. Amorphous forms not detected.
Nicotine	Air/XAD-4 sorbent tube (SKC 226-93)	1L/min Min.Vol. 60L, Max.Vol. 400L. Blanks required.	0.02μg/Tube	0.5mg/m^3	Modified Ogden Method (1989) NIOSH 2551, GCMS WCA 143	XAD-4 tubes are desorbed with ethyl acetate and analysed by GC/MS using SIM mode.
Nitric oxide and nitrogen dioxide	Air/3 x sorbent tubes connected in series. Molecular sieve/Oxidiser/ Molecular sieve. SKC 226-40 Molecular sieve (coated with triethanolamine)	0.025L/min for both NO and NO_2 0.2L/min for NO_2 only	1μg NO_2/sample	NO 25ppm 31mg/m^3 (TWA) NO_2 3ppm; 5.6mg/m^3 (TWA)	NIOSH 6014 (modified) OSHA ID-182 and ID-190	The sampling device contains three tubes in series. A molecular sieve coated with triethanolamine followed by an oxidiser tube and followed by another molecular sieve coated with triethanolamine. NO_2 is collected on the first tube; NO_2 passes through the first tube and is oxidised on the second tube and captured on the third tube. If NO_2 is sought only then one tube alone can be used.

Table 1 – Workplace monitoring analysis

Substance	Sample	Sample requirements	LOQ	Exposure	Method	Comments
Oil mist (Mineral Oil)	(25) or 37mm membrane filters 0.8 μm MCE, 5μm PVC, 2μm PTFE or glass fibre Blanks required For high concentrations use GFF	A sample of the oil producing the mist must be submitted with the sample(s) for calibration purposes 1–3L/min Min. Vol. 20 L @ 5mg/m^3 Max. Vol. 500 L	50μg/filter approx.	5mg/m^3 (TWA)	NIOSH Method 5026 (Modified)	The membrane filter is desorbed using a halogenated hydrocarbon solvent and then analysed using FTIR.
Organochlorines screen Aldrin, chlordane, dieldrin, heptachlor, DDT, HCB	Air/sorbent tube orbo 42 or 44 or SKC 226-49-102 (Orbo 42 small) or SKC 226-30-04 (Orbo 44); swab; soil. orbo 44 preferred but, can use orbo 42 (Large) or orbo 42 (small) SKC 226-30-16 (OVS)	0.2–1L/min. Min. Vol. 12L, Max.Vol. 240L Blanks required Swab – approx 2cm diameter.	10ng/tube 50ng/swab 100μg/Kg soil	Enquire at lab for relevant pesticide	In-house method GC WCA 103	Samples are desorbed or extracted with isooctane and analysed by GC using ECD.
Organophosphates screen Chlorpyrifos, Demeton-S, Diazinon, Dibrom, Dichlorvos, Disulfoton, Ethion, Fenamiphos, Fenclorphos, Fenthion, Mevinphos, Phorate, Prophos, Sulprofos, Tetrachlorvinphos	Air/25mm glass fibre filter, sorbent tube [SKC 226-30-16 (OVS) or SKC 226-30-05 or Orbo 608] or equivalent	0.2–1L/min. Min. Vol. 12L, Max. Vol. 240L Blanks required	0.1μg/tube	Enquire at lab	In-house method GCMS WCA 210	Samples are extracted with a toluene/ acetone solution and analysed by GC/MS.
Pesticides	Air/25mm glass fibre filter	1L/min	Enquire at lab	Enquire at lab	In-house method GCMS WCA 175	Pesticides are desorbed from filters with a suitable solvent and analysed by GC/MS.
Polychlorinated biphenyls (PCBs)	Air/Sorbent Tube (Orbo 60 or SKC ST 226-39); Swab; Soil. Iso-octane for swab obtainable from laboratory.	0.05–0.2L/min Min. Vol. 1L, Max. Vol. 50L Blanks required Cotton wool swab – approx 2cm diameter, soil: 1–10g.	1μg/tube 1μg/swab 1g/Kg soil	PCBs (42% chlorine) 1mg/m^3 PCBs (54% chlorine) 0.5mg/m^3	In-house method GC WCA 153	Samples are desorbed or extracted with isooctane and analysed by GC using ECD.
Phenol	Air/XAD-7 sampling tube (Orbo 47 or SKC 226-95)	Min.Vol. 1L, Max.Vol. 24L 0.1L/min for 4 hours	1μg/tube	4mg/m^3 (1ppm) TWA	OSHA No. 32 LC WCA 137	Samples are desorbed in methanolic sodium hydroxide solution and analysed by HPLC.

Table 1 – Workplace monitoring analysis

Substance	Sample	Sample requirements	LOQ	Exposure	Method	Comments
Phthalic anhydride	Air/GF filters	1L/min	5µg/sample	6.1mg/m^3 (1ppm) TWA	Modified NIOSH S179 LC WCA 168	Sample filters are desorbed using 0.2 M sodium hydroxide solution.
Polycyclic aromatic hydrocarbons (PAHs) Naphthalene Acenapthylene Acenaphthene Anthracene Benz(a) anthracene Benzo(b) fluoranthene Benzo(a) pyrene Benzo(ghi) perylene Benzo(k) fluoranthene Chrysene Dibenz(a,h)anthracene Fluoranthene Fluorene Indeno(1,2,3-cd)pyrene Phenanthrene Pyrene	Air/37mm 2µm PTFE filter and XAD-2 (SKC-226-30-04), Supelco Orbo 43 tube or equivalent	2L/min Min. 200L Max. 1000L Blanks required Wrap samples in aluminium foil and ship at cold on an ice-brick UV light may cause sample degradation.	0.1µg/sample	No current exposure standard except for naphthalene. (52mg/m^3; 10ppm) TWA exposures should be controlled to lowest practicable level	NIOSH method 5515 Modified and calif EPA Method 429 GCMS WCA178	Samples are extracted with cyclohexane and analysed by GC/MS using SIM Mode.
Pyrethroids Bifenthrin Bioallethrin Cyhalothrin Cypermethrin Deltamethrin Fenpropathrin Fenvalerate MGK-264 Permethrin Piperonyl butoxide	Glass fibre filter/XAD-2 OVS OVS tube assembly (SKC 226-30-16) or equivalent.	68-480 at 1L/min	0.01–0.1µg/filter or tube section	N/A	NIOSH Method 5008 (Modified) GCMS WCA 199	Filters and sorbent tubes are desorbed with acetonitrile and the desorbate analysed by GC/MS.
α-Quartz α-quartz + cristobalite reported	Respirable dust air/25mm PVC membrane filter GLA5000 5µm (Pall Corporation) or equivalent	Respirable dust (AS2985-2004) BCIRA cyclone 2.2L/min SIMPEDS 2.2L/min AL cyclone 2.5L/min	0.01mg/filter	0.1mg/m^3 (TWA)	NHMRC method for measurement of α-quartz in airborne dust by IR and XRD (1984). XRD WCA 220	Non-destructive technique. Amorphous (non-crystalline) forms of silica not detected. Free silica polymorphs (α-quartz, cristobalite and tridymite) resolved. Blank filters should be submitted.

Table 1 – Workplace monitoring analysis

Substance	Sample	Sample requirements	LOQ	Exposure	Method	Comments
α-Quartz	Bulk solids	Samples analysed as ground powder	1% w/w	NSW abrasive blasting regulations prohibits materials being used in a process that have any sand or free silica in them.	In House Method XRD WCA 115	Samples analysed as pressed powders using Siroquant software. Non-destructive technique. amorphous forms of silica not detected. Free silica polymorphs (α-quartz, cristobalite and tridymite) resolved.
Respirable dust	Respirable dust Air/25mm PVC membrane filter GLA 5000 (Pall Corporation) or equivalent, 5 μm 2L/min	Respirable dust (AS 2985-2009) BCIRA 2.2L/min SIMPEDS 2.2L/min AI cyclone 2.5L/min	0.01mg/Filter	2mg/m^3 amorphous fumed silica	WCA 191	A gravimetric determination of both a pre-weight and a post-weight sample is performed. It is preferable for both weights to be performed in the same laboratory.
Solvents – indoor air (Alcohols, aliphatic and aromatic hydrocarbons, chlorinated hydrocarbons, esters, ketones and complex solvents)	Air/charcoal tube (SKC 226-01)	0.02–0.2L/min for charcoal tube (1 to 100 L of air to be sampled depending on atmospheric concentration)	0.1μg/tube – hydrocarbons 0.2μg/tube – alcohols/ketones 0.2μg/tube – chlorinated hydrocarbons 1μg/tube – methylene chloride	Enquire at lab for relevant solvents	Modified NIOSH 1500 and 1501 GC WCA 154	Charcoal tubes are desorbed with CS_2 and analysed by GC using FID with 2 columns of different polarity at a sensitive setting. The use of passive monitors is not recommended.
Solvents – industrial air (Alcohols, aliphatic and aromatic hydrocarbons, chlorinated hydrocarbons, esters, ketones and complex solvents)	Air/charcoal tube (SKC 226-01) or passive monitor (3M 3500 or 3520) or SKC eqivalent	0.02–0.2L/min for charcoal tube (1 to 100 L of air to be sampled depending on atmospheric concentration) ½–1 workshift for passive monitor.	5μg/tube for simple solvents 50μg/tube for complex solvents	Enquire at lab for relevant solvents	Modified NIOSH 1500 and 1501 GC WCA 106	Charcoal tubes or passive monitors are desorbed with CS_2 and analysed by GC using FID with two columns of different polarity.
Sulfur dioxide	Air/IABC tube (SKC 226-80)	0.1L/min. 12L of air	1.0μg/tube	5.2mg/m^3 (TWA) 2 ppm	OSHA Method ID-200 (Modified), IC WCA 198	Samples are analysed as sulphate by HPLC/IC.
TGIC Triglycidyl isocyanurate	Air/37mm glass fibre filter, AE binder free	1L/min	2.5μg/sample	0.08mg/m^3 (TWA)	In House Method LC WCA 161	Filters are desorbed in aqueous acetonitrile solution and analysed by HPLC.

Table 1 – Workplace monitoring analysis

Substance	Sample	Sample requirements	LOQ	Exposure	Method	Comments
Unknown organics	Liquid, solid or sorbent tube	Samples should be submitted in air tight containers	Varies from 1–10 ppm in solution	Enquire at Lab	In House Method GCMS WCA 175	Analysis is performed by gas chromatography/ mass spectrometry (GC/ MS) in the scan mode.
Unknown inorganics (Crystalline substances)	Solid	Samples should be submitted in air tight containers	1–10% w/w for XRD analysis depending on matrix This is a qualitative analysis only 0.01% w/w for XRF analysis	N/A	In House Method XRF/XRD WCA 112 WCA 113	Analysis consists of an XRD scan for crystalline substances and an XRF Scan for 50 common elements of the periodic table.
Vinyl chloride	Coconut shell charcoal sorbent tube (SKC226-01) Preferably 2 tandem tubes	Flow rate: 0.05L/min Vol: 0.7L – 5L	0.1µg/tube	5ppm (TWA)	NIOSH 1007 MDHS 96, GCMS WCA 212	Preferably stored and transported in dry ice.
VOC scan See further for full list of 73 volatile organic compounds reported	Air/charcoal tube (SKC 226-01) or passive monitor (3M 3500 or 3520) or SKC equivalent	0.02–0.2L/min for charcoal tube (1 to 100 L or air to be sampled depending on atmospheric concentration) ½–1 workshift for passive monitor.	See list 73 compounds	Enquire at Lab	In House Method GCMS WCA 207	Charcoal tubes or passive monitors are desorbed with CS_2 and analysed by GC/MS.
Welding fumes	Welding fume Air/25mm PVC membrane filter GLA 5000 (Pall Corporation) or equivalent, 5 m 2L/min	2L/min	0.01mg/Filter	Welding fume 10mg/m^3	WCA 192	A gravimetric determination of both a pre-weight and a post-weight sample is performed. It is preferable for both weights to be performed in the same laboratory.

Volatile organics screen – 73 reported compounds and total VOC's*

	Aliphatic hydrocarbons (LOQ = 5µg)		Aromatic hydrocarbons (LOQ = 1µg)
1	2-Methylbutane	39	Benzene and TVOC
2	n-Pentane	40	Ethylbenzene
3	2-Methylpentane	41	Isopropylbenzene
4	3-Methylpentane	42	1,2,3-Trimethylbenzene
5	Cyclopentane	43	1,2,4-Trimethylbenzene
6	Methylcyclopentane	44	1,3,5-Trimethylbenzene
7	2,3-Dimethylpentane	45	Styrene
8	n-Hexane	46	Toluene
9	3-Methylhexane	47	p-Xylene and/or m-Xylene
10	Cyclohexane	48	o-Xylene
11	Methylcyclohexane		**Ketones (LOQ = 25µg)**
12	2,2,4-Trimethylpentane	49	Acetone
13	n-Heptane	50	Acetoin
14	n-Octane	51	Diacetone alcohol
15	n-Nonane	52	Cyclohexanone
16	n-Decane	53	Isophorone
17	n-Undecane	54	Methyl ethyl ketone (MEK)
18	n-Dodecane	55	Methyl isobutyl ketone (MIBK)
19	n-Tridecane		**Alcohols (LOQ = 25µg)**
20	n-Tetradecane	56	Ethyl alcohol
21	α-Pinene	57	n-Butyl alcohol
22	b-Pinene	58	Isobutyl alcohol
23	D-Limonene	59	Isopropyl alcohol
	Chlorinated hydrocarbons (LOQ = 5µg)	60	2-Ethyl hexanol
		61	Cyclohexanol
24	Dichloromethane		**Acetates (LOQ = 25µg)**
25	1,1-Dichloroethane	62	Ethyl acetate
26	1,2-Dichloroethane	63	n-Propyl acetate
27	Chloroform	64	n-Butyl acetate
28	1,1,1-Trichloroethane	65	Isobutyl acetate
29	1,1,2-Trichloroethane		**Ethers (LOQ = 25µg)**
30	Trichloroethylene	66	Ethyl ether
31	Carbon tetrachloride	67	tert-Butyl methyl ether (MTBE)
32	Perchloroethylene	68	Tetrahydrofuran (THF)
33	1,1,2,2-Tetrachloroethane		**Glycols (LOQ = 25µg)**
34	Chlorobenzene	69	Propylene glycol monomethyl ether
35	1,2-Dichlorobenzene	70	Ethylene glycol diethyl ether
36	1,4-Dichlorobenzene	71	Propylene Glycol monomethyl ether acetate
	Miscellaneous (LOQ #37 = 5µg and #38 = 25µg)	72	Cellosolve acetate
		73	Diethylene glycol monoethyl ether acetate
37	Acetonitrile		
38	n-Vinyl-2-pyrrolidinone		

*For charcoal sorbent tube or passive sampler devices. LOQ: Limit of quantitation.

Table 2 – Biological monitoring analysis

Exposure	Test	Sample	Collection	Biol. half-life	BOEL				Method, LOQ, technique	Comments
					SI units		Ref.	Mass units		
					/mol creatinine	/L		/L		
Metals (See also multi-element screening)										
Lead (See also multi-element screening)	Blood FEP (Free erythrocyte protoporphyrin)	10mL in heparinised tube	Timing not critical but level related to blood lead level 2–3 months prior to collection. Not affected by lead contamination of specimen.			1.8μmol/L	WCA	100μg/dL	WCA 132 0.5μmol/L FLUOR	Measure of lead effect on haem synthesis. Suitable test for both moderate and high levels (>3.0 μmol/L) of lead exposure. Marked increase can occur in iron deficiency anemia
Mercury (acute exp)	Blood mercury	10mL whole blood in heparinised tube	End of shift at end of work week	40–60 days		75nmol/L	ACGIH	15μg/L	WCA 223 20nmol/L ICPMS	BOEL refers to total mercury. Analysis measures inorganic mercury and some organic mercury if it is present. Blood mercury is for acute exposure – accidental spills. Dietary seafood can interfere in the blood test.
Mercury (chronic exp)	Urinary mercury	50mL urine in plastic container	Pre-shift at end of work week (following exposure in previous shift)	55 days	20μmol/mol cr	0.17μmol/L	ACGIH	35μg/L	WCA 215 20nmol/L ICPMS	BOEL refers to inorganic mercury. Urinary mercury is the preferred method of monitoring for medium to long term chronic exposure of at least six months or longer.

Table 2 – Biological monitoring analysis

Exposure	Test	Sample	Collection	Biol. half-life	BOEL				Method, LOQ, technique	Comments
					SI units		Ref.	Mass units		
					/mol creatinine	/L		/L		
Other chemicals										
Creatinine	This test is performed on each urine received at the laboratory	50mL in plastic container	Appropriate to analysis required	N/A	N/A	Normal Range 0.0027 – 0.0265 mol/L	ACGIH (WHO)	Normal range 0.3–3.0g/L	WCA 128 0.0005 mol/L SPEC	Urine results with a creatinine value outside the normal range are not reported relative to creatinine, – ie they are not creatinine corrected but reported relative to the volume of urine.
Cyanide	Urinary thiocyanate	50mL in plastic container	End of shift	Hours	–	–	Lauwerys	–	WCA 124 3μmol/L SPEC	Must be a non-smoker. Smoking causes increases in thiocyanate up to 250 μmol/L (28 mmol/mol creatinine). Dietary sources may be significant, especially consumption of leafy vegetables. Lauwerys has quoted a reference value of less than 6 mg/g creat. (11.7 mmol/mol creatinine or 103 μmol/L).
Cytotoxic drugs	Cyclophosphamide ifosfamide	50mL in plastic container	End of shift	3–12 hours					WCA 231 0.2μg/L LCMS	At present, no BOEL is set for cytotoxic drugs. However, it is considered that any level above the LOQ is indication of an exposure and that work practices should be reviewed. This does not necessarily have implications on a person's health.

Table 2 – Biological monitoring analysis

Exposure	Test	Sample	Collection	Biol. half-life	BOEL				Method, LOQ, technique	Comments
					SI units		Ref.	Mass units		
					/mol creatinine	/L		/L		
Fluoride	Urinary fluoride	50 mL in plastic container	Pre and post shift specimen recommended	4–7 hours	42mmol/mol cr	370μmol/L	DFG	7 mg/L	WCA 150 5μmol/L ISE	Note that since fluoride is usually present in reticulated water and as a consequence also in processed food, that levels up to 15% of the BOEL can be expected from dietary sources. Accumulation of fluoride in bones also occurs but chronic (>5 years) excessive exposure is required for the development of fluorosis. A non-occupationally exposed level should be below 52.6 μmol/L (1mg/L).
Methyl bromide	Blood bromide	10mL in heparinised tube	End of shift at end of work week	9–15 days	–	0.25 mmol/L	WCA	20mg/L	WCA 148 0.02mmol/L XRF	Nonspecific test. May be raised from dietary sources of bromine. A level of less than 0.07 mmol/L is considered normal.
MOCA 4,4′-Methylene bis-(2-chloroaniline)	Urinary MOCA	50mL in plastic container	End of shift at end of work week	20 hours	15μmol/mol cr	132nmol/L	HSE	35μg/L	WCA 187 25nmol/L GC	Exposure is by skin absorption which may not be apparent to the worker. This may explain variable MOCA excretion. MOCA levels are usually higher at the end of the shift and reflect exposure over the preceding 2–3 days.

Table 2 – Biological monitoring analysis

Exposure	Test	Sample	Collection	Biol. half-life	BOEL				Method, LOQ, technique	Comments
					SI units		Ref.	Mass units		
					/mol creatinine	/L		/L		
Pentachloro-phenol (PCP)	Urinary PCP (Total)	50mL in plastic container	Preshift at end of work week	Biphasic: (ingestion) 1.5 days 17 days (Urine)	0.25mmol/mol cr (0.85mmol/mol cr)	2.6nmol/L 2.3μmol/L (7.5μmol/L)	DFG ACGIH Under review	0.6mg/L (2mg/L)	WCA 166 10μg/L GC	Potential environmental contaminant. Small amounts (30 μg/L) may be present in the urine of persons not occupationally exposed.
Poly-chlorinated biphenyls (PCBs)	Blood PCB Screen	10mL in heparinised or EDTA tube	Not critical	Persistent	Not Set	(200μg/L unofficial guideline limit)			WCA.152 30μg/L GC	PCBs are mainly forms of arochlor. T½ arochlor 1242 (blood) 7-8 months. T½ arochlor 1260 (blood) 33-34 months Background level < 20 μg/L usually ≈ 1 μg/L.
Polycyclic aromatic hydrocarbons (PAHs)			End of shift	6–35 hours	0.5μmol/mol cr (under review)	5nmol/L (under review)	ACGIH	1.0 μg/L (under review)	WCA 158 0.5μg/L LC	1-Hydroxypyrene is considered to be a suitable biological marker for exposure to polycyclic aromatic hydrocarbons.
Pesticides										
Herbicides	Urinary herbicide screen Bromoxynil Clopyralid Dicamba Picloram Triclopyr 2,4-D	50mL in plastic container	End of shift or end of work week if using every day.	 hours hours hours hours 5–6 hrs 12–22 hrs			 WCA WCA WCA WCA	 Not set Not set 100μg/L 100μg/L 100μg/L 100μg/L	WCA 102 10μg/L GC	Urine collections must be made within 48 hours of last exposure.

Table 2 – Biological monitoring analysis

Exposure	Test	Sample	Collection	Biol. half-life	BOEL				Method, LOQ, technique	Comments
					SI units		Ref.	Mass units		
					/mol creatinine	/L		/L		
	Urinary glyphosate	50mL in plastic container	End of shift	6 hours				Not set	WCA 136 25µg/L LC	Urine collections must be made within 48 hours of last exposure. Literature indicates glyphosate is not easily absorbed through skin.
	Urinary MCPA (4-chloro-2-methyl phenoxy acetic acid)	50mL in plastic container	End of shift	hours				Not set	WCA 193 10µg/L GCMS	Urine collections must be made within 48 hours of last exposure.
Organo-chlorine insecticides	Blood organochlorine insecticide screen	10mL in heparinised or EDTA tube					WCA WCA	150µg/L 50µg/L 100µ/L 20µg/L	WCA 101 2µg/L GC	Chlordane and heptachlor are stored in adipose tissues and are measured in blood as the metabolite heptachlorepoxide. Aldrin breaks down to give the metabolite dieldrin.
	Hexachloro-benzene Dieldrin DDT (total) Heptachlorepoxide		Not critical Not critical Not critical Not critical	Persistent Persistent Persistent Persistent						
	Endosulfans	10mL in heparinised or EDTA tube	End of shift	hours				Not set		Endosulfans rarely detected due to rapid metabolism.
Organo-phosphorus insecticides	Urinary alkyl phosphate metabolites	50mL in plastic container	Post shift or next day after use	1–2 days	Not set				WCA 203 For detection limits see further LCMS	See Additional Information Organophosphate metabolites for further information.

Table 2 – Biological monitoring analysis

Exposure	Test	Sample	Collection	Biol. half-life	BOEL				Method, LOQ, technique	Comments
					SI units		Ref.	Mass units		
					/mol creatinine	/L		/L		
Solvents										
Benzene	S-Phenyl-mercapturic acid in urine	50mL in plastic container	End of shift	9 hours	11.8μmol/mol cr	0.10 μmol/L	ACGIH	25μg/L	WCA 211 0.5μg/L LCMS	Sorbic acid is not a confounding factor for measuring benzene exposure via the urinary metabolite S-Phenylmercapturic acid. The background level for a non-smoker is 2.0 μg/g creatinine and for a smoker it is 3.6 μg/g creatinine.
Carbon disulfide	2-Thiothiazolidine-4-carboxylic acid (TTCA)	50mL in plastic container	End of shift	4–6 hours	(1μmol/mol cr pending)	(3μmol/L pending)	ACGIH	(500μg/L pending)	WCA 234 0.3μmol/L LCMS	This BOEL is a biological monitoring guidance value therefore, test results above do not necessarily mean adverse health effects will occur.
Cresol	Urinary cresol	50mL in plastic container	Pre and post shift	3 hours	–	1.8mmol/L	DFG	0.2g/L	WCA 145 0.05mmol/L LC	Dietary sources may be significant. Pre and post shift samples are recommended o and m forms not normally found in urine. p-form occurs in range 21–210 mmol/mol creatinine. Average 94 mmol/mol creatinine.
Ethyl benzene	Urinary mandelic acid	50mL in plastic container	End of shift at end of work week	4 hours	520mmol/mol cr	4.6mmol/L	ACGIH	0.69g/L	WCA 125 0.3mmol/L LC	Ethyl benzene may accumulate in the body during the working week. Major metabolites are mandelic acid (64%) and phenylglyoxylic acid (25%).

Table 2 – Biological monitoring analysis

Exposure	Test	Sample	Collection	Biol. half-life	BOEL				Method, LOQ, technique	Comments
					SI units		Ref.	Mass units		
					/mol creatinine	/L		/L		
Furfural	Urinary furoic acid	50mL in plastic container	End of shift	2–2.5 hours	200mmol/mol cr	1.77 mmol/L	ACGIH	200mg/L	WCA 186 0.01mmol/L LC	Furfural is metabolised very rapidly in the body (2–2.5 hrs), therefore sample collection is critical. Furoic acid is a natural constituent of human urine derived from dietary sources, particularly fructose. Its average concentration is in the order of 15 mmol/mol creatinine.
Isocyanates (HDI, 2, 4-TDI, 2, 6-TDI and MDI)	Urinary isocyanate metabolites (HDA, 2, 4-TDA, 2, 6-TDA and MDA)	50mL in plastic container	End of shift	2–4 hours	(1μmol/mol cr pending)	(0.009 μmol/L pending)	HSL	(1.5μg/L pending)	WCA 229 0.003μmol/L LCMS	This BOEL is a biological monitoring guidance value; therefore, the test results above do not necessarily mean that adverse health effects will occur. Isocyanates are known to cause respiratory sensitisation and asthma. Airborne exposure should be minimised. Dermal absorption can also be significant.
Phenol	Urinary Phenol	50mL in plastic container	End of shift	1–4 hours	–	2.1mmol/L	DFG	200mg/L	WCA 145 0.05mmol/L LC	Very rapidly excreted in the urine following exposure.

Table 2 – Biological monitoring analysis

Exposure	Test	Sample	Collection	Biol. half-life	BOEL				Method, LOQ, technique	Comments
					SI units		Ref.	Mass units		
					/mol creatinine	/L		/L		
Solvents (Acetone, Ethyl Acetate, Methylethyl ketone (MEK), Methylisobutyl ketone (MIBK), Ethanol, Cyclohexanol, Tetrahydrofuran (THF), Toluene, Methylene Chloride, 1,1,1-trichloroethane)	Urinary solvent screen	50 mL in plastic container	End of shift	hours		Acetone: 0.86 mmol/L MEK: 0.03 mmol/L MIBK: 0.02 mmol/L THF: 28 µmol/L (Toluene: 0.326 µmol/L pending) Methylene Chloride: 3.5µmol/L	ACGIH	Acetone: 50mg/L MEK: 2mg/L MIBK: 2mg/L THF: 2mg/L (Toluene: 0.03mg/L pending) Methylene Chloride: 0.3mg/L	WCA 163 0.05mg/L except for Ethanol, (0.5 mg/L) GCMS	
Styrene	Urinary mandelic acid	50 mL in plastic container	End of shift	Biphasic: 3–4 hours 25–40 hrs (urine)	297mmol/mol cr	2.6mmol/L	ACGIH	400mg/L	WCA 125 0.3mmol/L LC	Mandelic acid and phenylglyoxylic acid are the major metabolites of styrene. They are initially excreted rapidly in the urine following exposure then slowly over several days. The BOEL is for an exposure measured as mandelic and phenylglyoxylic acids.
Tetrachloroethylene	Urinary trichloroacetic acid	50 mL in plastic container	End of work week	2-4 days (urine)	–	0.02 mmol/L	ACGIH	3.5mg/L	WCA 146 0.01mmol/L GC	

Table 2 – Biological monitoring analysis

Exposure	Test	Sample	Collection	Biol. half-life	BOEL				Method, LOQ, technique	Comments
					SI units		Ref.	Mass units		
					/mol creatinine	/L		/L		
Toluene	Urinary hippuric acid	50mL in plastic container	End of shift	1–3 hours (urine)	1010mmol/mol cr	9mmol/L	ACGIH	1.6g/L	WCA131 0.5mmol/L LC	Hippuric acid is the major metabolite (64%) of toluene. However, dietary sources (certain vegetables and fruits and the preservative sodium benzoate) may also be metabolised to hippuric acid in significant amounts. Although o-Cresol is only a minor metabolite(1%) of toluene, it is more specific than hippuric acid. Test is recommended only if hippuric acid levels are high as a confirmation exposure to toluene.
	Urinary o-Cresol	50mL in plastic container	End of shift	3 hours (urine)	0.5mmol/mol cr	4.6μmol/L	ACGIH	0.5mg/L	WCA 145 0.05mmol/L LC	
1,1,1-trichloro-ethane (Methyl chloroform)	Urinary trichloroacetic acid	50mL in plastic container	End of shift at end of work week	2-4 days (urine)	–	–	–	–	WCA 146 0.01mmol/L GC	
Trichloro-ethylene	Urinary trichloroacetic ccid	50mL in plastic container	End of shift at end of work week	2-4 days (urine)	–	0.12 mmol/L	DFG	20mg/L	WCA 146 0.01mmol/L GC	
Xylenes	Urinary toluric acid (methyl hippuric acid)	50mL in plastic container	End of shift	Biphasic: 3.6 hours 30 hours (urine)	650mmol/mol cr	5.7mmol/L	HSE	1.1g/L	WC 131 0.05mmol/L LC	Toluric acid is the major metabolite (95%) of xylenes. Metabolism of xylene to toluric acid is inhibited (-50%) by ethanol and aspirin.

Table 2 – Biological monitoring analysis

Multi-element screening in urine by ICPMS

The inductively coupled plasma mass spectrometer (ICPMS) has the ability to provide multi-element analysis.

The laboratory screens for the following 13 elements in urine.

The urine samples (20 mL in MSU container) should be collected at the end of shift, preferably at the end of the working week.

	Exposure	Biol. half-life	BOEL				LOQ	Comments
			µmol/mol creatinine	SI units	Mass units	Ref.		
1	Antimony	4 days					0.01µmol/L	The urinary concentration has been determined to be approximately equivalent to = 5.87 + 0.52Sb in air (when Sb in air is in µg/m3) The upper 95% of the population background level of urinary antimony was 0.00002 mol/L (≅ 2.6ng/g creatinine)
2	Beryllium	20 days soluble 1 year insoluble					0.05µmol/L	At present, there is no clear relationship between beryllium internal dose and toxic effects. However, sensitisation to beryllium can occur via all routes of exposure and lead to chronic beryllium disease. The urinary beryllium concentration is generally below 13µmol/mol creatinine (111nmol/L) and mean values have been reported as low as 3.5µmol/mol creatinine (31nmol/L) in the general population. Smokers also usually show levels below 13µmol/mol creatinine (111nmol/L), but on average have levels higher than non-smokers.
3	Bismuth	5 days					0.01µmol/L	Bismuth compounds are considered to be poorly to moderately absorbed after inhalation or ingestion, but there is no quantitative data. Ingested bismuth is largely eliminated unabsorbed in faeces, however, absorbed bismuth is mainly excreted in urine. For the general population, the total daily intake in food is approx 5–20 µg.
4	Cadmium (chronic exp)	20 years	5 µmol/mol cr	44nmol/L	5µg/L	ACGIH	0.02µmol/L	The measurement of cadmium in urine estimates chronic exposure. However, it may provide no information on integrated exposure during the first year of exposure. In the workplace the lungs are the major route of absorption of aerosols, dusts and fumes. The main route of elimination is renal. Renal tubular damage from cadmium or renal tubular dysfunction of other etiologies results in increased renal elimination of cadmium.
5	Chromium	Triphasic 7 hours 15–30 days 3–5 years	10µmol/mol cr	0.09 µmol/L	5µg/L	HSE	0.02µmol/L	This BOEL is for exposures to hexavalent chromium which is reduced to trivalent chromium when it enters the body. Elimination of chromium is triphasic with half-lives of 7 hours, 15-30 days, and 3–5 years. The background level of chromium in urine should be <4.0 µmol/mol creatinine. Concentrations of chromium in preshift samples reflect past exposure, whereas post-shift sample values reflect both past and current exposures; therefore, it is recommended that a pre-shift and post-shift sample be taken.

Table 2 – Biological monitoring analysis

	Exposure	Biol. half-life	BOEL				LOQ	Comments
			µmol/mol creatinine	SI units	Mass units	Ref.		
6	Cobalt		29µmol/mol cr	0.25 µmol/L	15µg/L	ACGIH	0.02µmol/L	The form of cobalt in the inspired air (particle size, solubility) has an effect on the air urine concentration relationship. The BOEL should be applied for all cobalt and inorganic compounds, except cobalt oxides. Sampling time and avoidance of sample contamination are critical. This test is indicative of exposure over a number of days.
7	Copper	1 month				Lauwerys	0.02µmol/L	The unexposed concentration of copper in urine is approximately 50µg/g creatinine (89µmol/mol creatinine or 0.79µmol/L).
8	Lead (organic)		27µmol/mol cr	0.24 µmol/L	50µg/L	DFG	0.01µmol/L	Urine is the preferred matrix for exposure to organic lead (eg alkyl lead additives of petrol). This test is not recommended for exposures to inorganic lead.
9	Manganese (chronic exp)	2–5 weeks					0.02µmol/L	The unexposed concentration of manganese in urine is usually 0.2–3.4µmol/mol creatinine. Manganese in urine reflects recent exposure. Better interpretation of exposure is obtained on a group basis as excretion rates vary with dose. It has been suggested that blood and urine measurements are useful for confirming exposure.
10	Nickel	20-27 hours					0.04µmol/L	The absorption rate is generally dependent on the solubility of the compound. Levels of nickel in biological media markedly increase following inhalation of soluble compounds (such as nickel chloride, sulfate or nitrate), however poorly soluble compounds (such as nickel carbonate, sulfide or oxide) result in lesser, but more prolonged elevation. Recent studies indicate that in non occupationally exposed subjects, the concentration of nickel in urine is usually below 3.9 µmol/mol creatinine (2 µg/g creatinine).
11	Selenium	Biphasic 1–3 days 30–110 days					0.40µmol/L	The general population selenium values in urine are generally below 43 µmol/mol creatinine (380 nmol/L) (P 95%: 44µmol/mol creatinine (391nmol/L); Mean: 32µmol/mol creatinine (280 nmol/L)). Occupational exposure is expected to fall below 1265 nmol/L.
12	Thallium	15–30 days					0.004µmol/L	Following absorption, thallium rapidly appears in the urine, which is the main excretory pathway. Excretion, however, is slow and levels may remain elevated for several weeks (half-life is between 15 to 30 days). The concentration of thallium in the urine is generally below 0.83 µmol/mol creatinine (7.3nmol/L). Occupational exposure is expected to fall below 245nmol/L (28µmol/mol cr or 50µg/L).
13	Uranium	Biphasic 2 days 50–60 days					0.003µmol/L	The determination of uranium in urine is used to evaluate recent exposure to soluble uranium salts. It has been proposed that to prevent renal damage, the post shift urine concentration of uranium should not exceed 120µmol/mol creatinine(1050nmol/L). Background population levels range from 0.01 to 0.14µmol/mol creatinine (0.1 to 1.3nmol/L).

Table 2 – Biological monitoring analysis

	Exposure	Biol. half-life	BOEL				LOQ	Comments
			µmol/mol creatinine	SI units	Mass units	Ref.		
14	Vanadium	15–40 hours	110µmol/mol cr	0.98 µmol/L	50µg/L	ACGIH	0.02µmol/L	Absorption of vanadium is mainly via the respiratory route with very little of the ingested amount being absorbed. The skin is a minor route of absorption. The background level of vanadium in urine of an unexposed person should be less than 2.2µmol/mol creatinine. Workday exposure is best assessed by pre and post shift comparisons. Monday morning samples might reflect accumulation of the metal in the body. Vanadium is eliminated in the urine with a half-life of 15–40 hours.

Table 2 – Biological monitoring analysis

Speciation of arsenic in urine by LC/ICPMS								
Exposure to arsenic is determined by the analysis of the following four metabolites in urine TestSafe Method Number: WCA.218 The urine samples (20 mL in MSU container) should be collected at the end of shift, preferably at the end of the working week.								
	Exposure	**Biol. half-life**	**BOEL**				**LOQ**	**Comments**
			µmol/mol creatinine	**SI units**	**Mass units**	**Ref.**		
1	Monomethyl arsonic acid (MMAv)		–				0.02µmol/L	The Biological Occupational Exposure Limit of 0.470µmol/L is for inorganic arsenic that is classified as an IARC category 1 carcinogen. The ACGIH has recommended that the test result be not reported adjusted to creatinine, however, the creatinine result is provided separately in order to assist with the interpretation of the test result. 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. Fish and shellfish contain organic arsenic compounds such as arsenobetaine (AB) and a small amount of DMAv, which are excreted in urine unchanged. MMAv is the metabolite of exposure to As(III) and/or As(V). DMAv is present in seafood and is the main metabolite of exposure to As(III) and/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. Total Inorganic Arsenic test result is the summation of MMAv + DMAv + As(III) + As(V) and this value is compared to the BOEL.
2	Dimethyl arsinic acid (DMAv)		–				0.02µmol/L	
3	Arsenic (III)		–				0.02µmol/L	
4	Arsenic (V)		–				0.02µmol/L	
5	Total inorganic arsenic	1–4 Days	–	0.470 µmol/L	35µg/L	ACGIH	0.02µmol/L	
6	Dietary arsenic – arsenobetaine						0.02µmol/L	Arsenobetaine is only present in seafood

Table 2 – Biological monitoring analysis

Multi-element screening in blood by ICPMS

The inductively coupled plasma mass spectrometer (ICPMS) has the ability to provide multi-element analysis.

The laboratory screens for the following four elements in blood. Testsafe Method Number: WCA 214.

The blood samples (10 mL in heparinised tube) can be collected anytime taking care to avoid contamination.

	Exposure	Biological half-life	BOEL mass units	Ref	LOQ	Comments
1	Cobalt	Biphasic A few days months-years	17nmol/L		10nmol/L	Cobalt in blood collected at the end of the last shift of the workweek is an indicator of recent exposure to cobalt or its inorganic compounds. Cobalt oxides are less soluble and therefore should show lower levels. The background cobalt levels should not exceed the BOEL. However, persons with surgical implants or on cobalt containing medication for the treatment of anemia may show higher levels. The biological half-life of cobalt in blood is 29 hours.
2	Cadmium	2 months	44nmol/L		20nmol/L	Measurements of cadmium in blood are an indication of recent exposure to cadmium. Monitoring in blood should be preferred during the initial year of exposure and whenever changes in the degree of exposure are suspected. Measurements of cadmium in urine are the most widely used biological measure of chronic exposure to cadmium.
3	Lead	Triphasic 6 weeks 6 months 20 years	2.4μmol/L		0.1μmol/L	Blood is the preferred matrix for measuring exposure to inorganic lead whereas urine is the preferred matrix for measuring exposure to organic lead (eg alkyl lead additive of petrol). Most blood lead is contained within the erythrocytes. Blood lead levels are falling in the general community and most levels will be less than 0.7μmol/L in males and less than 0.5 μmol/L in females.
4	Manganese	Hours	364nmol/L		100nmol/L	

Additional information about the organophosphate metabolites in urine screen

Abbreviation	Name	Limit of detection	Creatinine adjusted detection limitsfor a urine with 1 g/L (0.010 mol/L) creatinine
DMP	Dimethylphosphate	1.5 μmol/L (200 μg/L)	150 μmol/mol creatinine
DMTP	Dimethylthiophosphate	0.2 μmol/L (25 μg/L)	20 μmol/mol creatinine
DMDTP	Dimethyldithiophosphate	0.2 μmol/L (25 μg/L)	20 μmol/mol creatinine
DEP	Diethylphosphate	0.7 μmol/L (100 μg/L)	70 μmol/mol creatinine
DETP	Diethylthiophosphate	0.2 μmol/L (25 μg/L)	20 μmol/mol creatinine
DEDTP	Diethyldithiophosphate	0.2 μmol/L (25 μg/L)	20 μmol/mol creatinine

Technique: Liquid chromatography with tandem mass spectrometry.

This test measures occupational exposure to organophosphate pesticides which when absorbed are excreted in the urine as either one or more of the following alkyl phosphate metabolites (breakdown products).

International studies of the urinary excretion of these metabolites in the general population have shown that on average, the levels found are below the detection limits of this method.

Metabolite(s)*	Organophosphate pesticide
DEP, DETP	Chlorfenviphos, chlorpyrifos, diazinon, parathion, pirimiphos-methyl, pyrazophos
DEP, DETP, DEDTP	Azinphos-ethyl, ethion, phorate, terbufos
DMP	Dichlorvos, mevinphos, monocrotophos, trichlorphon
DMP, DMTP	Azamethiphos, chlorpyriphos-methyl, famphur, fenitrothion, fenthion, omethoate, parathion-methyl, temephos, tolclofos-methyl, vamidothion
DMP, DMTP, DMDTP	Azinphos-methyl, dimethoate, malathion, methidathion, phosmet

**One or more of these metabolites would be expected.*

Guidelines for interpreting results

- Levels of dialkyl phosphates in urine below 100 μmol/mol creatinine would be considered to be a low occupational exposure and equivalent to a high non-occupational exposure.
- Levels of dialkyl phosphates in urine between 100 and 1000 μmol/mol creatinine would indicate that the person has had an occupational exposure to organophosphates and therefore work practices may need to be reviewed to reduce exposure levels.
- Levels of dialkyl phosphates in urine above 1000 μmol/mol creatinine would indicate a high occupational exposure to organophosphates and may be associated with a drop in the blood cholinesterase level.
- For workers with chronic exposure to organophosphates the dialkyl phosphate level in urine may also be associated with a drop in the blood cholinesterase level.

Abbreviations used in table 1 and table 2

Instrumental techniques

CVAAS	Cold vapour atomic absorption spectrophotometry
ECHD	Electrochemical detection
FTIR	Fourier transform infrared spectroscopy
GC	Gas chromatography with flame ionisation or electron capture detection
GCMS	Gas chromatography with mass spectrometry detection with/without headspace sampling
LC	High performance liquid chromatography with fluorescence, ultra-violet wavelength, electrochemical or conductivity detection
LCMS	Liquid chromatography - (mass spectrometry)
IC	Ion chromatography
ICPMS	Inductively coupled plasma mass spectrometry
ISE	Ion selective electrode
LCICPMS	Liquid chromatography - inductively coupled plasma mass spectrometry
PLM	Polarising light microscopy with dispersion staining
SPEC	Spectrophotometry with visible wavelength detection
XRD	X-ray diffractometry
XRF	X-ray fluorescence spectrometry

Other abbreviations used

ACGIH	American Conference of Governmental Industrial Hygienists
AIOH	Australian Institute of Occupational Hygienists
AS	Australian Standard
BOEL	Biological Occupational Exposure Limit
DFG	Deutsche Forschungsgemeinschaft (Germany)
HSE	Health and Safety Executive (United Kingdom)
LOD	Limit of detection
LOQ	Limit of quantitation
LAUWERYS	'Industrial Chemical Exposure Guidelines for Biological Monitoring' Lauwerys and Hoet, 2001
NHMRC	National Health and Medical Research Council (Australia)
NIOSH	National Institute of Occupational Safety and Health (USA)
OSHA	Occupational Safety and Health Administration (USA)
WCA	WorkCover Authority of NSW

Laboratory accreditation

The Chemical Analysis Branch is accredited with the National Association of Testing Authorities, Australia (NATA), for compliance to the international standard ISO/IEC 17025. Under a Memorandum of Understanding, the Commonwealth Government recognises NATA as the sole national accreditation body for establishing competent laboratory practice. The cornerstone of NATA accreditation is peer/expert assessment whereby the laboratory is assessed for technical competence. This ensures that the laboratory is always up to date with new technical developments and trends. By complying with the requirements of ISO/IEC 17025, the laboratory also meets most of the requirements of the international standards ISO 9001 and ISO 9002. ISO/IEC 17025 provides further guidance for laboratories by covering several technical competence requirements that are not covered by ISO 9001 or ISO 9002.

The ISO/IEC 17025 standard covers areas including:

- laboratory management
- quality control
- documentation control
- review procedures for requests
- tenders and contracts
- purchasing services and supplies
- client service including customer complaints management
- non-conforming work policy
- internal audit systems
- corrective action procedures
- management reviews
- technical requirements – eg personnel, accommodation and environmental conditions
- test method selection and validation
- appropriate equipment
- measurement traceability and measurement uncertainty.

Quality assurance

In order to ensure the highest degree of accuracy in the analytical results, the laboratory undertakes extensive intra-laboratory and inter-laboratory quality assurance (QA) activities. Within the laboratory, staff analyse laboratory and field blanks and perform duplicate and repeat analysis of samples. Spiked QA samples are also included routinely in each run to ensure the accuracy of the analyses. For many years, the branch has participated in several national and international inter-laboratory comparison programs including:

- Workplace Analysis Scheme for Proficiency (WASP) and Asbestos in Materials Scheme (AIMS) conducted by the Health and Safety Executive, United Kingdom
- Quality Management in Occupational and Environmental Medicine QA Program conducted by the Institute for Occupational, Social and Environmental Medicine, University of Erlangen, Germany
- Quality Control Technologies QA Program, Australia.
- Royal College of Pathologists QA Program, Australia.
- Organic Vapour Monitor Analysis Program conducted by 3M.

Measurement uncertainty

The branch is currently issuing a large number of its reports with an estimation of the measurement uncertainty. The measurement uncertainty is an estimate attached to a measurement that characterises the range of values within which the true value is asserted to lie. Every measurement has an uncertainty associated with it, resulting from errors arising in the various stages of sampling and analysis and from a limited knowledge of factors affecting the result. For measurements to be of practical value it is necessary to have some knowledge of their reliability. A statement of uncertainty is a quantitative estimate that tries to address this issue. A wide variety of factors make any analytical measurement result liable to deviate from the true value. As far as reasonably possible, such errors are minimised by external control or explicitly corrected for. The exact deviation of a single measurement result from the (unknown) true value is, however, impossible to obtain, both because the different factors vary from experiment to experiment and because the effects of each factor on the result is never known exactly. The likely range of deviation is therefore estimated.

Useful references and websites

ACGIH	American Conference of Governmental Industrial Hygienists TLV's and BEI's, Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices acgih.org
AGRO	The Agrochemicals Handbook. 3rd Edition. Royal Society of Chemistry. 1991. Editor H. Kidd. ISBN: 0-85186-416-3
AIHA	American Industrial Hygiene Association aiha.org
AIOH	Australian Institute of Occupational Hygienists aioh.org.au
BOHS	British Occupational Hygiene Society bohs.org
CCH	Laboratory Safety Manual. By the Occupational Health and Safety Unit of the University of NSW. R Haski, G. Cardilini and W. Bartolo. CCH Australia Limited. First published in October 1992 but continually updated. ISBN: 1-86264-439-X
HSE	Health and Safety Executive, United Kingdom hse.gov.uk
HSL	Health and Safety Laboratory, United Kingdom hsl.gov.uk
LAUWERYS	Industrial Chemical Exposure Guidelines for Biological Monitoring. Lauwerys and Hoet 2001. ISBN: 0-87371-650-7 3rd edition.
NATA	National Association of Testing Authorities, Australia. For a listing of accredited laboratories throughout Australia and their terms of accreditation nata.com.au
NIOSH	NIOSH Manual of Analytical Methods, 4th Edition, 1994. US Dept. of Health and Human Resources. National Institute for Occupational Safety and Health, Cincinnati, Ohio cdc.gov
OMH	Occupational Medicine Handbook. Information for Medical Practitioners. 11th Edition. 2003. Editor Dr K Wooller. ISSN: 1320-8624
OSHA	OSHA Analytical Methods Manual, Occupational Safety and Health Administration. US. Dept. of Labor, Salt Lake City osha.slc.gov
PESKEM	Peskem. The Australian Directory of Registered Pesticides and Their Users. Continually updated by the centre for Pesticide Application and Safety, University of QLD, Gatton College. ISSN: 1038-5789
SA	Standards Australia standards.com.au
Safe Work	Safe Work Australia. Exposure Standards for Atmospheric Contaminants in the Occupational Environment Guidance Note NOHSC: 3008, National Exposure Standards NOHSC: 1003 May 1995. ISBN: 0644-451475 swa.gov.au

For comprehensive information about safety testing including hazardous substances and occupational hygiene testing, visit testsafe.com.au

For information about work health and safety, visit workcover.nsw.gov.au or call **13 10 50**.

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