File No: NA291

Date: 5 March *1996*

NATIONAL INDUSTRIAL CHEMICALS NOTIFICATION AND ASSESSMENT SCHEME

FULL PUBLIC REPORT

Bis (2,4,4-trimethylpentyl) phosphinic acid

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Director
Chemicals Notification and Assessment

FULL PUBLIC REPORT

Bis (2,4,4-trimethylpentyl) phosphinic acid

1. APPLICANT

Cytec Australia Limited of Suite 1,1st Floor, 7-11 Railway St, Baulkham Hills, NSW 2153 has submitted a standard notification statement in support of their application for an assessment certificate for Bis (2,4,4-trimethylpentyl) phosphinic acid.

2. IDENTITY OF THE CHEMICAL

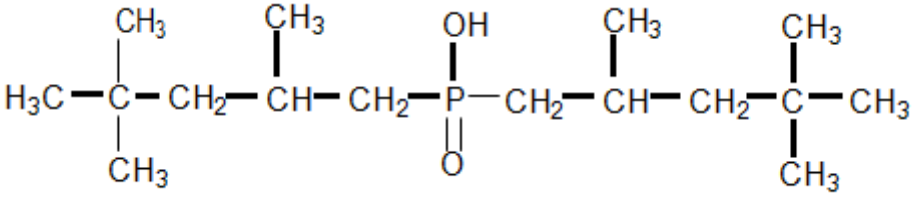
Chemical name: Bis (2,4,4-trimethylpentyl) phosphinic acid

Chemical Abstracts Service (CAS) Registry No.: 83411-71-6

Other names: None known

Trade name: Cyanex 272 Extractant

Molecular formula: $C_{16}H_{35}P0_2$



Structural formula:

Molecular weight: 290

Method of detection and determination: The chemical can be detected by infrared spectroscopy, titration and gas chromatography. Methodology was provided for the latter two.

Spectral data:	An infrared spectrum was provided for the chemical with peaks at 1670, 2300 and 2650 cm^{-1} (characteristic for phosphinic acids).

3. PHYSICAL AND CHEMICAL PROPERTIES

Appearance at 20^{0}C and 101.3 kPa:	**Colourless to** light amber liquid
Boiling Point:	>300 °C (at 760 mm Hg)
Specific Gravity:	0.92 at 24 °C
Vapour Pressure:	Not determined but expected to be very low due to the high boiling point
Water Solubility:	16 mg/L at pH 2.6; 38 mg/L at pH 3.7; with increasing pH, solubility is expected to increase
Partition Co-efficient (n-octanol/water) log P_{0w}:	K_{ow}>450; log $P_{0\sim}$>2.7 (determined by shake-flask method)
Hydrolysis as a function of pH:	See Comments Below
Adsorption/Desorption:	Not determined. The applicant states that due to extensive recycling, releases to the environment are likely to be insignificant
Dissociation Constant pKa:	4 x 10~ (at 25 ^{0}C; solvent 75% isopropanol:water by volume)
Flash Point:	108 °C
Flammability Limits:	Non-flammable
Autoignition Temperature:	Non-flammable
Explosive Properties:	Stable
Reactivity/Stability:	Not reactive

Comments on Physico-Chemical Properties

The technical bulletin on Cyanex 272 Extractant presented by the notifier indicates that the notified chemical is stable at pH 5 and 50 ^{0}C for four weeks. Under environmental conditions hydrolysis of Cyanex 272 Extractant is not expected.

Adsorption/desorption was not determined but the notified substance may be expected to moderately attach to the organic fraction in soil due to the moderate octanol/water coefficient. Cyanex 272 Extractant is also likely to attach to soil cations, reducing it's mobility in soil (based on technical bulletin provided by the notifier).

4. PURITY OF THE CHEMICAL

Degree of purity: 85-87%

Toxic or hazardous impurity/impurities: None known

Non-hazardous impurity/impurities (> 1% by weight):

Chemical name:	Tris (2 4,4-trimethylpentyl) phosphine oxide
Weight percentage:	10-12%

AdditiveslAdjuvants: None known

5. INDUSTRIAL USE

The notified chemical will be used in the mineral processing industry where it will be used as an extractant in mining operations. A 10% solution with an organic liquid detergent will be used to separate zinc and iron from cobalt solutions.

The chemical has been confirmed for use at one site Australia in the purification of cobalt from iron and zinc. Potentially it could be used at approximately 5 other sites for the separating/purification of a number of base metals.

The notified chemical will be imported in 200 L tight-head high density polyethylene drums at a rate of> 1 tonne per annum.

6. OCCUPATIONAL EXPOSURE

It will be imported to Australia in 200 L tight head density polyethylene drums in containers and transported to Cytec Australia's warehouse in Sydney. At the warehouse the containers will be unpacked and the drums either stored or transported

to the industrial customers. Ten to 20 workers (including waterside workers, drivers and warehouse workers) will be involved in transport and handling of the material from the wharf to the warehouse and another 10 to 15 (warehouse workers and drivers) from the warehouse to industry. As no repacking or reformulation will be carried out by these workers, exposure to the chemical will result only in the event of accidental spillages.

At the customer sites process operators (numbers not specified) will attach and disconnect automatic dosing systems into the imported drums (approximately 10 times per year). Exposure during these operations will be of very short duration and should not result in any significant exposure.

The automatic dosing systems will deliver the chemical directly into enclosed extraction systems. The extractant will then be recycled via an enclosed stripping system. As both these processes are completely enclosed and automated, no worker exposure is anticipated. Workers will however be required to sample the liquor in the extraction systems into bottles via sample valves (approximately 6 times a week; 1 minute per sampling). These workers will be required to wear eye protection, gloves, safety boots, overalls and a canister face mask (if necessary).

7. PUBLIC EXPOSURE

No public exposure to the notified chemical is expected during its distribution.

The solvent extraction process is stated to be highly automated and will be conducted in enclosed systems, and therefore no public exposure to the notified chemical is expected to occur. Minimal waste is anticipated during the extraction process as a 'solvent recycle system' will be employed which is known to reduce Cyanex 272 Extractant in waste streams to <1 mg/L. Any waste will be treated at the effluent treatment plant, and the resultant solid waste, containing the notified chemical, will be disposed in accordance with relevant local, state and federal government requirements. Industrial use and disposal of the notified chemical are not expected to result in any significant public exposure.

8. ENVIRONMENTAL EXPOSURE

The process at the customer site involves extraction of the iron and zinc impurities from the raw aqueous cobalt solution using the notified chemical and organic solvents. The organic solvent and Cyanex 272 Extractant from the extraction section are sent to the stripping section, where the iron, zinc and other impurities are removed from the solvent/Cyanex 272 Extractant, before the organic phase is returned for reuse. The aqueous streams from the extractor and the stripping section are passed through two further separators to recover the maximum amount of solvent and Cyanex 272 Extractant, which are reused. The other potential users are expected to use similar methodology and technology in their operations. (The other potential users are currently in either the design or construction phase of their processing facilities.)

Release

Release to the environment during the transport and storage of the product would be confined to breakages caused by transport accidents. Release from the imported containers is expected to be rare. Dispensing is to be done in closed systems which are largely automated, therefore minimising possible spills. Any spills that do occur during transport or formulation are to be treated according to instructions in the Material Safety Data Sheet (MSDS). Spills are to be adsorbed using sand or earth and transferred to drums. Disposal of spilt material is to be in accordance with federal, state and local regulations.

As a result of the high cost of the notified chemical, releases to the environment are expected to be kept to a minimal. Almost all of the Cyanex 272 Extractant used is recycled within the plant with the solvent. The notifier estimates that approximately 10% of the initial charge will be required as a top-up per annum.

Releases from the customer site are expected to be minimal. As a result of the low pH used in the extractor (approximately pH 3), the concentration of Cyanex 272 Extractant in the aqueous extract is expected to be <2 ppm (technical bulletin on Cyanex 272 Extractant presented by the notifier). The aqueous solution from the separator, containing the cobalt, is further treated to remove the cobalt. It is unclear what happens to the waste from the cobalt recovery plant but it is expected to eventually end up in the tailings dam, from which the effluent liquid is returned to the processing plant. The other aqueous stream from the stripping area (where the iron/zinc is stripped from the organic extract) is stated by the applicant to contain <1 ppm of Cyanex 272 Extractant and is returned to the main nickel processing plant.

The waste iron and zinc solids from the stripping plant are disposed of as solid waste in accordance with relevant local, state and federal government requirements. It is anticipated that most of this solid waste will be sent to the tailings dam or landfilled in a pit. The amounts of Cyanex 272 Extractant in this solid waste is unknown.

Fate

The fate of most of the notified chemical is disposed in the tailings dam, where it will be adsorbed to particles in the tailings. The applicant states that the effluent from the tailings dam is returned to the processing plant for reuse. Some of the notified chemical will be disposed of with the iron-zinc solid waste.

There is no information on the degradation of the notified chemical. However, the notifier has presented the results (no report) of a similar chemical, Cyanex 301, in the OECD Closed Bottle Test as 13% BOD in 28 days. (Cyanex 301 is the dithio analogue of Cyanex 272.) Phosphate esters are known to oxidise from the thio form to the oxo and a similar reaction could occur for dithiophosphinic acids, which could be attributed to the percentage degradation noted.

The moderate solubility and log P_{O-} together with the molecular weight indicate that bioaccumulation is possible. However, bioaccumulation is not expected due to the

limited environmental exposure anticipated.

9. EVALUATION OF TOXICOLOGICAL DATA

9.1 Acute Toxicity

Table 1 Summary of the acute toxicity of Cyanex 272 Extractant

Test	Species	Outcome	Reference
Acute oral toxicity	Rat	$LD_{50} > 3500$ mg/kg	(1)
Acute dermal toxicity	Rat	$LD_{50} > 2000$ mg/kg	(1)
Skin Irritation	Rabbit	severe irritant	(2)
Eye irritation	Rabbit	severe irritant	(1)
Skin sensitisation	Guinea-pig		(3)

9.1.1 Oral Toxicity (1)

LD_{50}: > 3S00 mg/kg

Result. low oral toxicity *Species/strain.* Rat, Sprague-Dawley

Number/sex of animals: SM, SF *Observation period:* 14 days

Method of administration (vehicle): gavage

Mortality: 2F (day 1), 1M (day 2)

Test Method. based on OECD Guidelines for Testing Chemicals (4).

9.1.2 Dermal Toxicity (1)

LD_{50}: > 2000 mg/kg
Result: severe irritant *Species/strain:* Albino rabbits
Number/sex of animals: 10 males *Observation period.* 14 days

Method of administration (vehicle): By occluded patch to abraded skin; 24 hour exposure.

Modality: no deaths *Clinical signs:* this was a combined dermal toxicity/irritation study see below for irritant effects.

Draize Scores' (5):

Time after treatment (days)	Animal #									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
ERYTHEMA										
1	2	2	4	4	4	3	4	4	3	3
2	2	4	4	4	4	2	4	4	2	3
3	2	4	4	4	4	2	4	4	2	3
OEDEMA										
1	4	3	4	4	4	4	4	4	4	4
2	3	3	3	3	3	4	4	3	3	3
3	3	3	3	3	2	4	4	3	3	3

I See Attachment 1 for Draize Scales.

Test Method: based on OECD Guidelines for Testing Chemicals

9.1.4 Skin Irritation (2)

Result: slight irritant *Species/strain.'* Albino rabbit

Number/sex of animals: 6 males

Method of administration: **a** neat sample of the notified chemical was applied under occluded dressing for 24 hours.

Draize Scores[i] (5):

Time after treatment (days)	Animal #					
	1	**2**	**3**	**4**	**5**	**6**
ERYTHEMA						
1	1	1	1	1	1	1
3	0	0	0	0	0	1
OEDEMA						
1	2	1	2	1	2	2
3	1	1	0	1	1	1

[1]See Attachment 1 for Draize Scales

Test Method. based on OECD Guidelines for Testing Chemicals (4).

9.1.5 Eye Irritation (1)

Result: Severe irritant

Species/strain.' Albino rabbits *Number of animals:* 9 males

Method of administration: 0.1 mL into conjunctival sac of one eye. For 6 animals the treated eyes were not irrigated; for 3 animals the treated eyes were irrigated for 1 minute, 20-30 seconds after instillation.

Test Method.' based on OECD Guidelines for Testing Chemicals (4).

Draize Scores' (5):

Unirrigated Eves

Animal	**Time after instillation**									
	1 day		**2 days**		**3 days**		**4 days**		**7 days**	
CORNEA	opacity	area	opacity	area	opacity	area	opacity	area	opacity	area
1	0		1	4	1	4	0		0	
2	0		1	2	1	3	1	3	0	
3	0		1	4	1	4	2	4	3	4
4	0		1	3	1	4	2	4	1	3
5	1	4	2	4	2	2	1	2	0	
6	2	4	2	4	2	4	1	4	0	

IRIS															
1	0			0			0			0			0		
2	0			0			0			0			0		
3	0			0			0			0			0		
4	0			0			0			0			0		
5	0			0			0			0			0		
6	0			0			0			0			0		
CONJUNCTIVA	r[a]	c[b]	d[c]	r[a]	c[b]	d[c]	r[a]	c[b]	d[c]	r[a]	c[b]	d[c]	r[a]	c[b]	d[c]
1	2	3		1	1	2	1	1	1	0	1	1	0	0	0
2	2	3	3	2	2	2	2	2	2	1	2	2	0	0	0
3	1	2	2	1	1	1	3	2	1	3	2	2	2	1	1
4	2	2	2	1	2	2	2	2	1	2	2	1	1	2	1
5	1	2	2	1	2	1	1	2	1	0	1	0	0	0	0
6	2	4	3	2	3	2	2	3	2	2	2	1	1	1	0

[a] redness chemosis [c] discharge

'See Attachment 1 for Draize Scales

Irrigated Eyes: No corneal or iridal effects; 2 animals exhibited no conjunctival redness, 1

animal slight redness on days 1 and 2; 2 animals exhibited slight chemosis on day 1, 1 animal moderate chemosis on day 1 and mild chemosis on days 2 and 3; 2 animals exhibited slight discharge on day 1, 1 animal mild discharge on day I and slight discharge on days 2 and 3.

9.1.6 Skin Sensitisation (3)

Result: non-sensitiser

Species/strain.' Guinea pig/ Dunkin/Hartley *Number of animals:* 20 test, 10 control

Induction.' Three pairs of injections of 0.1 mL: FCA in water (1:1); 0.25% notified chemical in Alembicol D with and without FCA (1:1). Topical induction: at day 6, 0.2 mL 10% sodium lauryl sulphate in petrolatum followed 1 day later by 0.4 mL neat notified chemical for 48 hours.

Results.' use of 5O% and 100% v/v notified chemical produced reactions in the controls which, while not suggestive of sensitisation, made scoring imprecise. Therefore a second challenge was conducted one week later as follows:

Challenge Concentration	**24 hrs**		**48 hrs**	
	test	**control**	**test**	**control**
25%	0/20	0/10	0/20	0/10
5O%	0/20	0/10	0/20	0/10

Test Method.' based on OECD Guidelines for Testing Chemicals (4).

9.2 Repeated Dose Toxicity

Not supplied. This was acceptable as there will be minimal potential for repeated occupation exposure under normal use situations.

9.3 Genotoxicity

9.3.1 Salmonella typhimurium Reverse Mutation Assay (6)

Result: non-mutagenic

Strains.' *Salmonella typhimurium* TA 98, TA 100, TA 1S3S, TA 1S37, TA 1S38 and *Escherichia coli* WP2*uvr*A

Concentration range.' 33 - 10000 ~ig/ plate with and without rat liver S9

Test Method.' based on OECD Guidelines for Testing Chemicals (4).

9.3.2 Micronucleus Assay in the Bone Marrow Cells of the Mouse (7)

Result.' negative (sampling times 24, 48 and 72 hours post-dosing). A borderline result at the 48 hour time point was confirmed as negative in a second study.

Species/strain.' mouse/ Swiss SPF CD-i

Number and sex: SM, SF *Doses.'* 900 mg/kg

Method of administration (vehicle).' gavage (1 % methylcellulose)

Test Method.' based on OECD Guidelines for Testing Chemicals (4).

9.4

Overall Assessment of Toxicological Data

Cyanex 272 Extractant showed low oral toxicity (LD_5O >3500 mg/kg) and dermal toxicity (LD_5O >2000 mg/kg) in rats. When tested in rabbits it was a severe skin irritant, a severe eye irritant to non-irrigated eyes and a moderate eye irritant following irrigation. The chemical was not a skin sensitiser in guinea pigs. In the presence and absence of metabolic activation, the chemical was not mutagenic in bacteria and did not produce chromosome aberrations in a mouse micronucleus study. No repeat dose toxicity study was provided.

On the basis of submitted data, the notified chemical would not be classified as hazardous in accordance with Worksafe Australia's *Approved Criteria for Classifying Hazardous Substances* (8) in relation to Acute lethal effects (oral, dermal); Sensitising effects (skin) or Mutagenic effects. However based on the chemosis scores presented in the submitted eye irritancy test, as well as the skin irritancy reported in the submitted acute dermal toxicity study, the chemical would be classified as hazardous.

10. ASSESSMENT OF ENVIRONMENTAL EFFECTS

The following ecotoxicity studies have been provided by the notifier. The fish studies are old studies (December 1981) and were conducted according to US EPA "Methods for acute toxicity test with fish, 197S". Small globules of the test material were noted on the surface in the fish studies. The results are also based on the nominal concentrations for these studies.

The *daphnia* studies were performed to modern standards (OECD and US EPA requirements). The *daphnia* results are actual concentrations in solution as measured.

Test	Species	Results
Acute toxicity	Rainbow trout	96h LC_{50} 22 $mg.L^{-1}$ NOEC = 7.7 $mg.L^{-1}$
Acute toxicity	Bluegill	96h LC_{50} 46 mg. L^{-1}
		NOEC = 22 mg. L^{-1}
Acute toxicity	*Daphnia magna*	48h EC_{50} > 9.9 mg. L^{-1}
		NOEC = 2.9 mg. L^{-1}

The ecotoxicity studies show that the notified chemical's toxicity to fish was higher than the solubility in the test media and the results could reflect the physical effect of the oily globules on the fish's gills. The results show that Cyanex 272 Extractant is slightly toxic to aquatic organisms. Effects on aquatic organisms are possible when the chemical is released to waterways.

There was no information on algae toxicity.

11. ASSESSMENT OF ENVIRONMENTAL HAZARD

With the continuous reuse of Cyanex 272 Extractant, releases of chemical from the plants where it is to be used is expected to be minimal. At the proposed customer, the two aqueous solutions (one from the extractor and the other from stripping the organic/Cyanex 272 Extractant phase) will be treated before being reused within the facility. The Cyanex 272 Extractant in these aqueous streams is expected to be diluted in the facility before being sent to the tailings area, where the water will be returned to the processing facility. Some of the chemical is expected to be adsorbed to the solids in the tailings dam. The solids waste from the stripping plant is also expected to contain some Cyanex 272 Extractant. These solids are expected to be sent to the tailings dam or buried in a pit. The concentration of Cyanex 272 Extractant in the tailings dam is unknown but there is expected to be between 200-500 kg per annum of chemical added each year as a top-up. This amount includes some losses due to degradation in use and that disposed of via the tailings dam.

In normal operations there should not be any releases from the tailing dam to the environment on a ongoing basis. Release could occur during heavy rain due to flooding of the tailings dam. In this case there would be large dilution of the overflow from the tailings dam in the flooded streams, which would reduce the hazard to low levels and reduce the risk to negligible.

At the end of the mine's life, the processing plant will be decommissioned. The solvent used containing the notified chemical is expected to be disposed of according to the relevant federal, state and local government regulations. Currently disposal would be by incineration or sent to a solvent recycler for reuse.

Similarly the tailings dam will be decommissioned according and relevant federal, state and local government requirements. It is expected this will involve stabilising the dam and site rehabilitation. Leaching of the notified chemical is possible;
however as other phosphoric acid compounds, eg glyphosate (9) are known to bind strongly to soil cations to form adsorbent-cation-complex, a similar process is expected for the notified chemical due to the strong affinity to iron and aluminium, major soil cations (technical bulletin on Cyanex 272 Extractant presented by the notifier). Leaching of the notified chemical from the tailings dam is not expected.

Degradation of the notified chemical within the tailings dam is not known but it is unlikely due to the low biological activity within the tailings dam.

The environmental exposure is expected to be limited and therefore the hazard is negligible.

The only other sources of environmental contamination during normal usage is from accidental spills etc. The MSDS is adequate to limit the environmental exposure from spills etc and together with the expected strong binding to soil and moderate Kow the environmental effects from possible accidentals should be negligible.

The overall environmental hazard can be rated as negligible.

12. ASSESSMENT OF PUBLIC AND OCCUPATIONAL HEALTH AND SAFETY EFFECTS

Cyanex 272 Extractant is stable, non-flammable and is expected to exhibit low volatility. Based on the submitted data, the major toxicological concerns associated with Cyanex 272 Extractant will be severe skin and eye irritation.

During the use of the chemical, occupational exposure will be limited to workers involved with the extraction process. This process will be conducted in an enclosed mineral extraction system in which the extractant is recycled. Workers may be potentially exposed via dermal or eye exposure while fitting dosing system connections to the imported drums. They may also be exposed via these routes during liquor sampling. Inhalational exposure is unlikely as the chemical is a nonvolatile liquid and is unlikely to form aerosols or mists during normal use.

The personal protective equipment stipulated in the MSDS (impervious gloves and chemical splash goggles or full face shield) should be adequate to minimise exposure during the extraction process. Therefore, under normal use conditions, the notified chemical is not expected to present any significant health or safety risk to workers.

Given the industrial use pattern of Cyanex 272 Extractant, no significant public exposure is expected to occur.

13. RECOMMENDATIONS

To minimise occupational exposure to Cyanex 272 Extractant the following guidelines and precautions should be observed:

if engineering controls and work practices are insufficient to reduce exposure to Cyanex 272 Extractant to a safe level, then the following personal protective equipment which conforms to Australian Standard (AS) or Australian/New Zealand Standard (AS/NZS) should be worn:

safety goggles should be selected and fitted in accordance to AS 1336 (10) to comply with AS/NZS 1337 (11).

industrial clothing must conform to the specifications detailed in AS 2919 (12) and AS 376S.1 (13).

impermeable gloves or mittens conforming to AS 2161 (14) and AS 376S.1 (13).

all occupational footwear should conform to AS/NZS 2210 (15).

spillage of the notified chemical should be avoided.

good personal hygiene should be practised to minimise the potential for ingestion.

a copy of the Material Safety Data Sheet should be easily accessible to employees.

14. MATERIAL SAFETY DATA SHEET

The MSDS for Cyanex 272 Extractant was provided in Worksafe Australia format (16).

This MSDS was provided by Cytec Australia Limited as part of their notification statement. The accuracy of this information remains the responsibility of Cytec Australia Limited.

15. REQUIREMENTS FOR SECONDARY NOTIFICATION

Under the *Industrial Chemicals (Notification and Assessment) Act 1989,* secondary notification of Cyanex 272 Extractant shall be required if any of the circumstances stipulated under subsection 64(2) of the Act arise. No other specific conditions are prescribed.

16. REFERENCES

1. Bioassay Systems Corp. Project Number 11273, August 1982, *Single dose oral toxicity, primary eye irritation and combined dermal toxicity and irritation tests performed on [Cyanex 272 Extractant]..*

2. Bioassay Systems Corp. Project Number 11452, December 1982, *Primary dermal irritation test performed on Cyanex 272, Sample No. N-805-1-P.*

3. Huntington Research Centre, CTI 4/950098/SS,1995, *Cyanex 272 Extractant Skin sensitisation in the guinea pig.*

4. Organisation for Economic Co-operation and Development, *OECD Guidelines for Testing of Chemicals,* OECD, Paris, France.

5. Draize JH, 1959, 'Appraisal of the Safety of Chemicals in Foods, Drugs and Cosmetics', *Association of Food and Drug Officials of the US, 49.*

6. Huntington Research Centre, CTI-567-94, 1995, *Salmonella/Escherichia coli plate incorporation mutagenicity assay.*

7. Huntington Research Centre, CTI 3/9S0462, 1995, *Cyanex 272 Extractant Mouse micronucleus test.*

8. National Occupational Health and Safety Commission, 1994, *Approved Criteria for Classifying Hazardous Substances.* Australian Government Publishing Service, Canberra.

9. 5. M. Carlisle and J. T. Trevors, 1988, *Water, Air and Soil Pollution,* **39** 409-420.

10. Standards Australia, 1994, *Australian Standard 1336-1994, Recommended Practices for Eye Protection in the Industrial Environment,* Standards Association of Australia PubI., Sydney, Australia.

11. Standards Australia, Standards New Zealand, 1992, *Australian/New Zealand Standard 1337-1992, Eye Protectors for Industrial Applications,* Standards Association of Australia PubI., Sydney, Australia, Standards Association of New Zealand PubI. Wellington, New Zealand.

12. Standards Australia, 1987, *Australian Standard 2919 - 1987 Industrial Clothing,* Standards Association of Australia PubI., Sydney, Australia.

13. Standards Australia, 1990, *Australian Standard 3 765-1990 Clothing for Protection Against Chemical Hazards, Part I Protection Against General or Specific Chemicals, Part 2 Limited Protection Against Specific Chemicals,* Standards Association of Australia PubI., Sydney, Australia.

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15 Standards Australia, Standards New Zealand, 1994, *Australian/ New Zealand Standard 2210 - 1994 Occupational Protective Footwear, Part 1.' Guide to Selection, Care and Use. Part 2: Specifications,* Standards Association of Australia PubI., Sydney, Australia, Standards Association of New Zealand PubI. Wellington, New Zealand.

16. National Occupational Health and Safety Commission, 1994, *Code of Practice for the Preparation of a Material Safety Data Sheets,* Australian Government Publishing Service, Canberra.