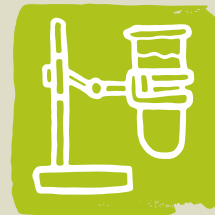
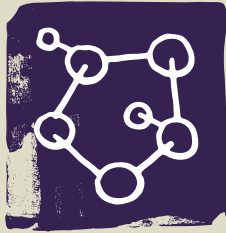




# Workplace Exposure Standards and Biological Exposure Indices

EFFECTIVE FROM JULY 2011  
6TH EDITION



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# CONTENTS

<b>CONTENTS</b> .....	<b>3</b>
<b>PREFACE</b> .....	<b>5</b>
Corrections to this edition .....	5
Acknowledgements.....	7
<b>BASIC RIGHTS AND RESPONSIBILITIES UNDER THE HEALTH AND SAFETY IN EMPLOYMENT ACT 1992</b> .....	<b>8</b>
What are the responsibilities for an employer? .....	8
Do employees have responsibilities? .....	8
<b>1. INTRODUCTION</b> .....	<b>9</b>
1.1 Target Audience.....	10
1.2 Legal Requirements.....	10
1.3 Limitations .....	10
1.4 Differentiation .....	11
1.5 Substances without a WES.....	11
1.6 Routes of Entry.....	11
1.7 Definitions .....	11
<b>2. APPLICATION AND CORRECTIONS OF WORKPLACE EXPOSURE STANDARDS</b>	<b>12</b>
<b>3. UNITS OF MEASUREMENT</b> .....	<b>14</b>
<b>4. MIXED EXPOSURES</b> .....	<b>15</b>
4.1 Independent Effects .....	15
4.2 Additive Effects.....	15
4.3 Greater than Additive Effects.....	16
<b>5. AEROSOLS</b> .....	<b>17</b>
5.1 Particle Deposition .....	17
<b>6. CARCINOGENS</b> .....	<b>20</b>
6.1 R-phrases and HSNO Equivalents for Carcinogenicity.....	21
<b>7. SKIN ABSORPTION</b> .....	<b>22</b>
<b>8. WORK LOAD</b> .....	<b>23</b>
<b>9. SENSITISERS</b> .....	<b>24</b>
<b>10. SIMPLE ASPHYXIANTS</b> .....	<b>25</b>
<b>11. INHALABLE AND RESPIRABLE DUSTS</b> .....	<b>26</b>
11.1 Inhalable Dust .....	26
11.2 Respirable Dust.....	28
<b>12. RUBBER FUME AND RUBBER PROCESS DUST</b> .....	<b>29</b>
<b>13. CARBON MONOXIDE (CO)</b> .....	<b>30</b>
Short-term Excursions for CO Exposure .....	30
<b>REFERENCE KEY FOR TABLE OF WORKPLACE EXPOSURE STANDARDS</b> .....	<b>32</b>
<b>1. BIOLOGICAL EXPOSURE INDICES</b> .....	<b>86</b>
1.1 Introduction .....	87
1.2 Exposure Periods .....	87
1.3 Effectiveness .....	87

1.4	Biological Assays .....	88
1.5	Legal Requirements.....	88
1.6	Issues with Biological Monitoring.....	88
1.7	Information prior to Monitoring.....	89
1.8	Sample Collection .....	89
1.9	Interpretation of Results .....	90
<b>2.</b>	<b>LEAD BIOLOGICAL EXPOSURE INDICES .....</b>	<b>91</b>
2.1	Female Employees .....	91
2.2	Recommended Blood Lead Levels.....	91
	<b>TABLE OF BIOLOGICAL EXPOSURE INDICES.....</b>	<b>94</b>
	<b>APPENDIX 1: DEFINITIONS.....</b>	<b>97</b>
	<b>APPENDIX 2: REFERENCES .....</b>	<b>105</b>

## PREFACE

The sixth edition of the Workplace Exposure Standards and Biological Exposure Indices has been developed by the Department of Labour (the Department) in conjunction with the Environmental Risk Management Authority (ERMA New Zealand) and Responsible Care New Zealand Incorporated. Input has also been sought from a wide range of interested parties.

It replaces and updates the December 2010 publication (5<sup>th</sup> edition), which contained typographical errors.

Exposure to hazardous or toxic substances continues to be one of the most significant causes of occupational ill health and injury, as identified by the National Occupational Health and Safety Advisory Committee (NOHSAC) in their 2005 report "*Surveillance of Occupational Disease and Injury in New Zealand*".

According to the report, it is estimated that each year in New Zealand:

- 700 to 1,000 people die from work-related disease
- 20,000 new cases of work-related disease and injury occur
- the cost of disease and injury totals \$20.9 billion.<sup>i,ii</sup>

Employers under the HSE Act and persons in charge of a workplace under the HSNO Act must ensure that they have systems in place to control hazardous exposures, and these systems may need to include air and/or biological monitoring.

The Department will continue to review and revise this document to take into account any significant new toxicological or industrial hygiene information. Amendments will be flagged with the year of change, for example: <sup>(2010)</sup>.

Corrections to the 6<sup>th</sup> edition will be flagged as <sup>(2011)</sup>.

### Corrections to this edition

Corrections in this edition comprise of the following:

Page	Substance	Error	Correction
7	Acknowledgements	Waallart	Wallaart
25	Oxygen	Incorrect maximum range 22%	23.5%
34	Acetic anhydride	Incorrect CAS [104-24-7]	[108-24-7]

---

<sup>i</sup> Pearce, N, Dryson, E, Feyer, A-M, Gander, P, McCracken, S, Wagstaffe, M (2004). *The burden of occupational disease and injury in New Zealand: Report to the Associate Minister of Labour*. NOHSAC: Wellington, 2004.

<sup>ii</sup> Access Economics (2006). *The economic and social costs of occupational disease and injury in New Zealand: Technical Report 4* NOHSAC: Wellington.

34	Acetophenone	Incorrect CAS [96-86-2]	[98-86-2]
34	Allyl propyl disulfide	Incorrect CAS [2179-559-1]	[2179-59-1]
36	Asphalt	Incorrect CAS [8502-42-4]	[8052-42-4]
37	Barium sulphate	Incorrect CAS [7227-43-7]	[7727-43-7]
37	Benomyl	Incorrect CAS [17804-39-3]	[17804-35-2]
39	Butyl mercaptan	Incorrect CAS [109-75-5]	[109-79-5]
40	Calcium carbonate	Incorrect CAS [1317-79-1]	[471-34-1]
40	Carbon black	Missing HSNO classification	6.7B
42	Chromite ore processing (Chromate), as Cr	"confirmed carcinogen"	6.7A
43	Chromium (VI) compounds, as Cr	"Certain water soluble" "confirmed carcinogen"	"Water insoluble" 6.7A
44	Cyclonite	Incorrect CAS [121-082-4]	[121-82-4]
47	Diethylene glycol monomethyl ether	Incorrect CAS [1675-54-3]	[111-77-3]
52	Fenamiphos	Incorrect CAS [2224-92-6]	[22224-92-6]
53	Graphite	Value 3 missing from mg/m <sup>3</sup>	3mg/m <sup>3</sup>
63	Mica	Incorrect CAS [12001-25-2]	[12001-26-2]
67	Pentachloronitrobenzene	Incorrect CAS [82-98-8]	[82-68-8]
68	m-Phenylenediamine	Incorrect CAS [108-42-2]	[108-45-2]
72	Resorcinol	Incorrect CAS [108-43-3]	[108-46-3]
73	Silica, crystalline	Missing HSNO classification	6.7A
75	Tantalum oxide	Incorrect CAS [1314-60-1]	[1314-61-0]
77	Triethanolamine	Incorrect CAS [105-71-6]; HSNO classification allocated in error	[102-71-6]; HSNO classification removed
81	Wood dust (hard and	HSNO classification	HSNO classification

	softwoods)	allocated in error	removed
82	Zirconium	Incorrect CAS [7440-67-2]	[7440-67-7]

### ***Changes carried over from the 5<sup>th</sup> edition***

1. **Formaldehyde:** the WES-Ceiling remains at 1ppm; however, WES-TWAs for eight hour and 12-hour shifts respectively have been introduced. The WES-TWA for eight hour shifts is 0.5ppm. The WES-TWA for 12 hour shifts is 0.33ppm. Implementation for both WES-TWA will be staged over one year from 13<sup>th</sup> December 2010.
2. **Softwood Dust:** a species classification list identifying hard- and softwood dust has been introduced. The WES-TWA for eight hour shifts for softwood dust has been reduced from 5mg/m<sup>3</sup> to 2mg/m<sup>3</sup>. The WES-TWA for 12 hour shifts is also 2mg/m<sup>3</sup>. The 12 hour WES-TWA will be reviewed as data supporting the development of a 12 hour WES becomes available.

Implementation for the amended WES will be staged over two years from 13<sup>th</sup> December 2010.

### **Acknowledgements**

The Department of Labour acknowledges the valuable assistance of the following contributors to this edition:

- Dr Michael Beasley, Medical Toxicologist, New Zealand National Poisons Centre, University of Otago
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- Dr Geraint Emrys, Chief Advisor Health and Safety, Department of Labour

Maarten Quivooy  
Group Manager, Workplace Services  
July 2011

## **BASIC RIGHTS AND RESPONSIBILITIES UNDER THE HEALTH AND SAFETY IN EMPLOYMENT ACT 1992**

### **What are the responsibilities for an employer?**

Employers have a responsibility to make the workplace safe, and to ensure the health and safety of those working in or visiting the workplace under their control. To achieve this, employers are expected to:

- Systematically identify hazards
- Systematically manage those hazards by eliminating them, isolating them or minimizing them, in that order of preference
- Provide suitable protective clothing and equipment to staff
- Provide safety information to staff
- Provide training and/or supervision so that work is done safely
- Monitor the environment and health of employees to ensure that their work is not having a detrimental effect on them
- Provide opportunities for employees to participate in the workplace's health and safety systems
- Record and investigate workplace accidents
- Report serious harm accidents suffered by employees to the Department of Labour.

### **Do employees have responsibilities?**

Yes. Employees are required to take all practicable steps to ensure their safety and others in the workplace. This includes considering both the things they do and the things they omit to do (such as not using safety equipment).

Employers should make clear to employees their responsibilities to use the provided safety equipment and to wear protective clothing. The expected level of an individual employee's responsibility will often be seen to increase with knowledge and seniority, but the employer's overall responsibility to ensure a safe workplace remains.

Practicable steps the employee can take also include reporting to the employer any hazards or incidents, so that the employer can investigate and put safeguards in place.

### ***Employees' health and safety rights***

Employees are entitled to:

- Receive, for no charge, the necessary protective clothing and equipment necessary to safely do their job
- Wear their own suitable protective clothing if they wish to provide it
- Receive the results of any monitoring conducted by the employer relevant to them or their workplace
- Receive reasonable opportunities to participate in workplace health and safety.

For further information on safety rights and responsibilities in the workplace, visit <http://www.osh.dol.govt.nz/order/catalogue/hseact-text/index.shtml>.

# Workplace Exposure Standards for Atmospheric Contaminants

# 1. INTRODUCTION

## 1.1 Target Audience

The Workplace Exposure Standards (WES) are intended to be used as guidelines for people qualified in occupational health practice.

Employers and people with duties under the HSE and HSNO Acts may use this book as a reference; but it is recommended that specialist advice is sought prior to engaging in monitoring programmes or hazard control.

It is not recommended that untrained persons use WES to determine “compliance”.

## 1.2 Legal Requirements

WES are an important tool for monitoring the workplace environment. Where hazardous or toxic substances exist in the same environment as workers, and the employer is unable to successfully eliminate or isolate these substances from working environments, he or she is required to minimise and monitor employee exposure.

Section 10 of the HSE Act requires employers to take “all practicable steps” to minimise hazards that cannot be eliminated or isolated. In workplaces where hazardous or toxic substances are present, section 10(2)(c) requires employers to take all practicable steps to monitor employees’ exposure to these substances.

Section 11(2)(b) of the HSE Act requires the employer to give results of monitoring to affected employees relating to their place of work, or their health and safety.

## 1.3 Limitations

Defining an exposure level that will achieve freedom from adverse health effects is the major consideration for assigning these WES. However, compliance with the designated WES level does not guarantee that all workers are protected from discomfort or ill-health. The range of individual susceptibility to hazardous and toxic substances is wide, and it is possible that some workers will experience discomfort or develop occupational illness from exposure to substances at levels below the WES.

WES are assigned to approximately 650 hazardous or toxic substances. About 50 substances have been removed from this edition because at the time of publication they were not approved for use in New Zealand under the HSNO Act.

In many cases well-documented data exist to help determine WES. But for some substances, the available toxicological and industrial hygiene information is insufficient to enable highly reliable standard-setting. Therefore, it is inevitable that some current WES will be lowered in the future, as more information about the effects from these substances becomes known.

## 1.4 Differentiation

WES must not be used to differentiate between safe and inherently hazardous exposure levels.

In addition, the numerical value of two or more WES must not be used to directly compare the relative toxicity of different substances.

Apart from any inconsistency that may result from the information that was available at the time the WES were set, the biological basis for assigning the WES also varies. Some WES are designed to prevent the development of ill-health after long-term exposure; others to reduce the possibility of acute effects. Also, the technical feasibility of limiting exposure varies from substance to substance, and in practice this may restrict the safety factor.

## 1.5 Substances without a WES

Many hazardous or toxic substances used in the workplace have not been assigned WES. However, this should not be taken to mean that these substances are necessarily safe under all conditions, and that no restriction should be placed on their use. Regardless of the substance, it is important to take all practicable steps to eliminate, isolate or minimise the concentration of airborne substances to the lowest practicable level.

## 1.6 Routes of Entry

Hazardous or toxic substances may enter the body following inhalation, ingestion or skin absorption. But in occupational settings, it is usually the inhalation aspect that is most important, partly because absorption, especially of vapours and gases, is usually greater from the respiratory tract than via skin.

However, substances listed with a skin notation<sup>(skin)</sup> are known to have potential for significant skin absorption (particularly from liquid, but also from other forms). This should not be ignored, because in these cases the total dose received through all absorption routes can be significantly higher than just that from respiratory absorption (such as might be roughly estimated from the airborne level). This is further discussed in the section on skin absorption (Section 7).

Exposure to airborne substances is usually measured directly with personal air sampling techniques, but in some situations, biological monitoring may be used as a complementary approach. Information on biological monitoring and a list of recommended indices is located in the second part of this publication.

## 1.7 Definitions

For definitions used in this publication, please see Appendix 1.

## 2. APPLICATION AND CORRECTIONS OF WORKPLACE EXPOSURE STANDARDS

Workplace Exposure Standards (WES) are calculated on the basis of an “assumed” work pattern of an eight hour working day and a 40 hour work week. In some cases, a correction is needed to take other work patterns into account. The following rules should be applied when designing monitoring programmes and assessing the results against the necessary WES.

### ***A. When the substance has a WES-Ceiling or a WES-STEL value***

When a WES-Ceiling or WES-STEL has been assigned, no correction for shift patterns is required. The exposure level is compared directly with the WES-Ceiling or WES-STEL value.

#### **Example 1:**

Substance: Hydrogen cyanide  
WES-Ceiling: 10ppm  
Work shift: 12 hours  
Exposure: maximum instantaneous exposure level 8ppm.

The peak exposure level during the shift of 8ppm is compared directly with the WES-Ceiling of 10ppm. The WES has not been exceeded.

### ***B. When the substance has a WES-TWA and the total exposure during the working day is eight hours or less***

For exposures up to eight hours, the average exposure over the time worked is compared directly with the WES-TWA. If a Ceiling or STEL has not been assigned, the default excursion of three times the WES for any 15-minute period applies.

#### **Example 2:**

Substance: Toluene  
WES-TWA: 50ppm  
Work shift: 8 hours  
Exposure: 60ppm averaged over 8 hours, including a 15-minute exposure of 200ppm

The WES-TWA has been exceeded because the average exposure during the work shift (actual exposure: 60ppm) was greater than 50ppm.

The general excursion that applies over any 15-minute period, which is 150ppm (3 times the WES-TWA of 50ppm) has also been exceeded (actual exposure: 200ppm).

**C. When the substance has a WES-TWA and the total exposure during the working day is over eight hours**

An adjustment is made to the WES by applying the following formula based on the Brief and Scala Model<sup>\*</sup>.

$$\text{Adjusted WES-TWA} = \frac{8 \times (24-h) \times \text{WES-TWA}}{16 \times h}$$

Where h = hours worked per day

**Example 3:**

Substance: Isopropyl alcohol

WES-TWA: 400ppm

WES-STEL: 500ppm

Work shift: 12 hours

$$\text{Adjusted WES-TWA: } \frac{8 \times (24-12) \times \text{WES-TWA}}{16 \times 12}$$

$$= \frac{8 \times 12 \times 400\text{ppm}}{16 \times 12}$$

$$= 200\text{ppm (12-hour WES-TWA)}$$

The average exposure over the 12-hour shift would then be compared with the 12-hour WES-TWA standard of 200ppm. The calculation is the same as that shown in Example A.

No adjustment is required for the WES-STEL.

<sup>\*</sup>The Brief and Scala Model adjustment process is a complex issue, and no single model provides a universal solution. The Model takes into account both the increased work hours and the decrease in the recovery period between shifts.

It is noted that in some circumstances that the Brief and Scala Model may be excessively protective. While in these cases the use of other models is not ruled out, they should only be applied when all of the relevant data is available. In particular, if a pharmacokinetic model is used, an understanding of the toxicology and pharmacokinetics of the substance is required. The adjustment of exposure limits is discussed in detail in *Patty's Industrial Hygiene and Toxicology*<sup>(1)</sup>.

### 3. UNITS OF MEASUREMENT

The concentration of a substance in air is either measured by volume (parts per million, or ppm), or by mass (milligrams per cubic metre of air, or mg/m<sup>3</sup>). WES for gases and vapours are expressed in ppm, with the units mg/m<sup>3</sup> also listed. In the case of particulates, the concentration is given in mg/m<sup>3</sup>.

If sampling for gases and vapours (in ppm) is conducted at a substantially different temperature or pressure than when the sampling equipment was calibrated, the result needs to be adjusted to account for the effect of temperature and pressure.

A temperature of 25°C and a pressure of 760 torr is used to convert ppm to mg/m<sup>3</sup>. The conversion equation is:

$$\text{WES in mg/m}^3 = \frac{\text{WES (in ppm)} \times \text{gram molecular weight of the substance}}{24.45}$$

To avoid significant differences between the values, the derived mg/m<sup>3</sup> values have been rounded to two or three significant figures – no increase in the precision of the WES is implied.

## 4. MIXED EXPOSURES

Generally, WES are listed for a single substance or a range of compounds with a common toxic entity (e.g. compounds of arsenic). In some instances, a WES has been set for a group of substances (e.g. petrol vapours).

Often a worker will be exposed to several substances over the working day. Before an assessment of the existing hazards can be made, it is important to determine the airborne concentration of each substance.

In some cases where this is not possible, it may be feasible to measure the concentration of another "marker" compound also present in the same material, and use the known relative concentrations of each compound stated in the composition details of the bulk material to estimate the remaining levels. However, this should only be attempted when there is good reason to believe that the proportions in the workplace air will mirror those in the original substance. It would not be valid, for example, to assume that the composition of vapour coming from a material containing a mixture of solvents of different volatilities can be anticipated from the solvent concentrations in the bulk material.

### 4.1 Independent Effects

If there is evidence to suggest that the actions of hazardous/toxic substances on the body are independent, the concentrations of each individual substance should be compared directly with their own WES value (-TWA, -STEL, or -Ceiling as appropriate).

This is most obvious when two (or more) substances have different toxic actions, and cause adverse effects on different target organs. For example, the low WES for benzene is because of its quite specific toxic actions on the bone marrow. This can occur at air levels substantially lower than those necessary for benzene (and most other solvents) to cause nervous system toxicity, as their WES are based on their toxicity to the nervous system. Therefore, their limits are higher than that for benzene, and the effects (and concentrations) of these other solvents should not be considered additive to that of benzene in evaluating benzene's exposure.

### 4.2 Additive Effects

Although it is simplistic, a pragmatic approach is to consider that the effects of substances with similar toxicological action are additive. This may be applied, for example, to a mixture of organic solvents with similar narcotic actions.

If the combined WES is not to be exceeded, then:

$$\frac{C_1}{WES_1} + \frac{C_2}{WES_2} + \frac{C_3}{WES_3} \dots \frac{C_n}{WES_n} \quad \text{should be less than 1}$$

where C = occupational exposure and WES = corresponding Workplace Exposure Standard.

**Example:**

Substance 1:	Toluene
TWA Exposure (mg/m <sup>3</sup> ):	70
WES-TWA:	188

Substance 2:	Xylene
TWA Exposure (mg/m <sup>3</sup> ):	190
WES-TWA:	217

Both substances act on the central nervous system. The WES for the mixtures is calculated as:

$$\frac{70}{188} + \frac{190}{217} = 0.372 + 0.876$$
$$= 1.24$$

Therefore, the WES for this mixture is exceeded.

### **4.3 Greater than Additive Effects**

The combined action may be greater than that predicted from the sum of the individual responses (synergistic effect), or a substance that is not itself toxic could enhance the effect of a toxic substance.

The present understanding of synergistic effects is far from complete, and emphasises the need for a prudent approach to be taken with mixed exposures. It is important that the assessment of all exposures should be made in consultation with suitably qualified and experienced persons; especially so with mixed exposures.

## 5. AEROSOLS

Airborne particulates, or aerosols, encountered in the workplace include dusts, fumes and mists.

**Dusts** are discrete particles suspended in air, originating from the attrition of solids (primary dusts) or the stirring up of powders or other finely divided materials (secondary dusts). Dusts encountered in the workplace typically contain particles covering a wide range of sizes.

**Fumes** are very small airborne solid particulates with diameters generally less than  $1\mu\text{m}$ . They may be formed by both thermal mechanisms (e.g. condensation of volatilised solids, or incomplete combustion) and chemical processes (e.g. vapour phase reactions). Agglomeration of fume particles may occur, resulting in the formation of much larger particles.

**Mists** are droplets of liquid suspended in air. They may be formed by the condensation of a vapour, or by mechanical actions such as the atomisation of liquids in spray systems.

### 5.0.1 Equivalent Aerodynamic Diameter (EAD)

A parameter used to predict the likely behaviour of a particle in air is its Equivalent Aerodynamic Diameter (EAD). The equivalent aerodynamic diameter of a particle of any shape and density is defined as the diameter of a sphere with a density of  $1.0\text{g}/\text{cm}^3$  which has the same terminal velocity of settling in still or laminarly flowing air as the particle in question.

### 5.0.2 Biological Effects

Airborne particulates are associated with biological effects such as:

- infectious;
- carcinogenic;
- fibrogenic;
- systemic;
- allergenic; and
- irritative.

The target site may be within the respiratory system itself or, if the effect is systemic, elsewhere in the body. The total concentration of the substance in air, either in terms of the weight or number of particles per unit volume, is not the only factor influencing its toxic potential. The particle size distribution also plays an important role, as it determines the fraction of the inhalable mass that is deposited at the different sites within the respiratory system.

## 5.1 Particle Deposition

Five mechanisms are responsible for the deposition of particles within the airways: impaction, sedimentation, diffusion, interception and electrostatic attraction.

**Impaction** occurs where an abrupt change in the direction of airflow occurs, resulting in the particle crossing the air stream and impacting on a surface. This

is most effective for particles larger than  $5\mu\text{m}$ . The majority of particles in this size range are unable to negotiate passages in the nose and pharynx.

**Sedimentation** refers to the settling of particles under their own weight, which is important in the medium to smaller airways for particles of 1 to  $5\mu\text{m}$ .

**Diffusion**, or Brownian Motion, results from collisions with gas molecules, and only becomes significant for particles less than approximately  $0.5\mu\text{m}$ . Diffusion is most effective in the alveoli and very small airways where the distances between the walls are small.

**Interception** involves particles of finite size being brought within one particle radius of a surface or obstacle as they follow the flow streamlines around the surface/obstacle. Collection via this mechanism increases with increasing particle size. Interception becomes the dominant capture mechanism for particles in the 0.1 to 1mm and larger size range.

**Electrostatic Attraction** occurs if electrical charges on either the particle or the surface, or both, create attractive electrostatic forces of sufficient magnitude to attract the particle to the surface.

Not all particles present in workplace air will be taken in through the nose or mouth. Other particles are inhaled and not deposited, but exhaled in the next breath. Particles of  $0.5\text{-}1.0\mu\text{m}$  size are not effectively removed by impaction, sedimentation or diffusion, and tend to be under-represented in the material deposited. Aerosols in this size range are not necessarily insignificant, however, because the forces that influence their low efficiency of collection in the respiratory system also act against their removal from workplace air.

The efficiency of deposition may also be influenced by other characteristics of the particles. Hygroscopic particles (e.g. sulphuric acid mist) will increase in size as they absorb water and the effective diameter may be greater than the observed. Fibres have a tendency to become aligned (longitudinally) in their airflow and are therefore able to penetrate further into the respiratory system than would be anticipated from consideration of their mass (or length).

Although it is possible to define mass fractions relating to various sites in the respiratory system, it is the inhalable and respirable fractions that are more commonly determined.

**Inhalable dust** is the portion (or fraction) of airborne dust that is taken in through the mouth and nose during breathing.

**Respirable dust** corresponds to the fraction of total inhalable dust that is able to penetrate and deposit in the lower bronchioles and alveolar region.

Inhalable and respirable dust fractions are defined and the collection techniques specified in Tables 3 and 4. Unless otherwise stated, the WES for dusts refers to inhalable dust. A WES of  $10\text{mg}/\text{m}^3$  for the inhalable fraction and  $3\text{mg}/\text{m}^3$  for the respirable fraction apply to insoluble particulates where there is no indication that a more stringent standard should apply (particulates not otherwise classified).

If there is doubt about the contribution that a toxic impurity in the dust may have to the overall hazard, then the levels of this impurity in air should be compared directly against the appropriate WES. For example, if the dust contains asbestos, then a specific determination for asbestos in air should be carried out.

## 6. CARCINOGENS

For cancers induced by exposure to atmospheric contaminants, the time between the initial exposure and diagnosis of disease is usually several years. This latency period may vary with the particular substance, the intensity and length of exposure, and the individual.

Evidence for the carcinogenicity of substances encountered in the workplace is obtained from both epidemiological and experimental (e.g. animal) studies. Practical limitations, including the difficulty in obtaining reliable estimations on the nature and degree of exposure in epidemiological studies, and the long latency period of occupational cancers, have inhibited the classification of carcinogens.

The existence of exposure thresholds defining no-effect levels has been theorised, but such thresholds for humans cannot be precisely identified and confirmed from the evidence provided by epidemiological or animal studies.

Substances which have been identified as confirmed or possible human carcinogens are noted in the Table of Workplace Exposure Standards. In general, the recommendations made by the ACGIH<sup>(2)</sup> for classifying workplace carcinogens have been adopted. When interpreting the risk posed by individual substances, the documentation that supports the WES should be consulted<sup>(2,3,4)</sup>.

In the previous editions of the Workplace Exposure Standards, three categories of carcinogens were listed:

**A1 Carcinogen – confirmed human carcinogen:** the substance was known to be carcinogenic to humans based on the weight of evidence from epidemiological studies.

**A2 Carcinogen – suspected human carcinogen:** human data was accepted as adequate in quality, but is conflicting or insufficient to classify the substance as a confirmed human carcinogen; or the substance is carcinogenic in experimental animals by dose(s), by route(s) of exposure, at site(s), of histological type(s), or by mechanism(s) considered relevant to worker exposure.

The A2 carcinogen rating was used primarily when there was limited evidence of carcinogenicity in humans, and sufficient evidence of carcinogenicity in experimental animals with relevance to humans.

**A3 Carcinogen – confirmed animal carcinogen with unknown relevance to humans:** the substance was carcinogenic in experimental animals at a relatively high dose, by route(s) of exposure, at site(s), of histological type(s), or by mechanism(s) that may not be relevant to worker exposure. Available epidemiological studies do not confirm an increased risk of cancer in exposed humans. Available evidence does not suggest that the agent is likely to cause cancer in humans except under uncommon or unlikely routes or levels of exposure.

Under HSNO legislation, two categories of carcinogens are described. They are used throughout this guideline for HSNO-approved hazardous substances:

**6.7A Carcinogen – known or presumed human carcinogen:** the substance is either known to be carcinogenic to humans, or data indicates sufficient evidence in animal studies to demonstrate a causal relationship between human exposure and the development of cancer, or an increase in tumours.

**6.7B Carcinogen – suspected human carcinogen:** data indicates limited evidence in humans or animals that exposure to the substance may lead to the development of cancer, or an increased incidence of tumours.

Hazardous substances approved under HSNO that were previously categorised as A1, A2 or A3 have been converted to the HSNO 6.7 classification in this edition. For carcinogenic substances that are not covered by HSNO legislation but are used in New Zealand under other legislation, their carcinogenic status has been described.

### 6.1 R-phrases and HSNO Equivalents for Carcinogenicity

R-phrases (European Union Risk Phrases), sometimes available on safety data sheets, can be converted in most cases to HSNO classifications. In some cases, there is no direct correlation between R-phrases and HSNO classifications, because some R-phrases cross the threshold for two classifications. Expert judgement may be required, preferably based on the data that triggered the R-phrase.

R-phrase	Hazard Statement	R-phrase details (where needed)	Default HSNO classification
R40	Limited evidence of a carcinogenic effect		6.7B
R45	May cause cancer		6.7A
R49	May cause cancer by inhalation		6.7A

**Table 1: R-phrases and HSNO Equivalents<sup>(5)</sup>**

Wherever technically feasible, substances that have been identified as confirmed or possible workplace carcinogens should be replaced by less hazardous substances. If this is not feasible, the hierarchy of control specified in the *Health and Safety in Employment Act 1992*<sup>iii</sup> must be strictly applied.

Where appropriate, environmental or biological monitoring should be employed to demonstrate that exposure is being kept to the lowest practicable level. All workers likely to be exposed to carcinogens must receive information about the hazards they face, and training in minimising exposure to those substances.

<sup>iii</sup> Section 8: Significant hazard to employees to be eliminated if practicable; Section 9: Significant hazards to employees to be isolated where elimination is impracticable; Section 10: Significant hazards to be employees to be minimised, and employees to be protected, where elimination and isolation is impracticable.

## 7. SKIN ABSORPTION

Some substances can penetrate intact skin, and this may result in a higher substance uptake than would have been expected from inhalation only. Uptake through the skin is not usually the most significant route of absorption, but there are exceptions. For example, skin contact with organophosphate pesticides is thought to account for the majority of uptake experienced when working with these products.

As the WES only takes into consideration the inhalation component, care should be taken when interpreting air sampling results where there is also a possibility of significant uptake through the skin. Respiratory protection may give a false sense of security. This is particularly important where vapour phase skin absorption occurs, as there may be no obvious contact between the skin and the substance. Biological monitoring for exposure may be a useful supplement to air sampling in these situations.

Substances that are considered to have potential for significant skin absorption are identified in the list of Table of Workplace Exposure Standards with a <sup>“(skin)”</sup> notation.

## 8. WORK LOAD

An increase in work load can influence the uptake of a substance by increasing the lung ventilation rates and blood flow. For gases and vapours, the extent of this increase is dependent on, among other factors, the solubility of the substance in the blood. If the substance is very soluble in blood, the uptake is related directly to the lung ventilation (in litres per minute), as this determines the speed of its access to the uptake site.

Lung ventilation depends on the minute ventilation rate (average volume of air breathed per minute) and peak inspiratory air flow (the instantaneous flow rate during the inhalation phase of the breath).

If the substance is only slightly soluble in blood, the blood circulation rate becomes the determining factor, and respiratory volume does not have a significant influence.

Exposure standards have generally been derived assuming a moderate work load. This factor should be borne in mind, especially where both the work load and exposure are high. The following table presents lung ventilation rates at different work loads:

1. to indicate if additional care should be taken in interpreting the monitoring results in relation to the WES; and
2. to determine the type and effectiveness of respiratory protection.

Information on the limitations of applying the flow rates is provided in AS/NZS 1715:2009 *Selection, Use and Maintenance of Respiratory Protective Equipment*. It should be noted that these ventilation rates represent average values and can vary substantially from individual to individual. Current research on values for peak inspiratory air flow indicate that these are underestimated at present.

Assessment of Work Load	Average ventilation rate litres/minute	Peak inhalation rate litres/minute
Low, e.g. writing, typing, small bench too work, standing while drilling or milling small parts	11-20	100
<b>Moderate</b> , e.g. hammering in nails, filing, pneumatic hammering, walking 3.5-5.5 km/h	<b>20-31</b>	<b>150</b>
High, e.g. carrying heavy loads, shovelling, digging, pushing or pulling heavy cart, walking 5.5-7.0km/h	31-43	200
Very high, e.g. working with axe, intense shovelling or digging, climbing ladder, stair or ramp, walking in excess of 7km/h	43-56	250

**Table 2: Lung Ventilation Rates Impacted by Work Load**

## 9. SENSITISERS

Exposure to some substances can lead to the development of an allergic sensitisation, usually affecting the skin or respiratory system. High exposures may hasten the onset of the allergy, but once developed in an individual, very low exposures can provoke a significant reaction.

Even though low exposure standards have been specified for known sensitisers, the levels do not necessarily provide adequate protection for an already sensitised person. Avoiding further exposure may be the only option for these individuals.

A number of substances, including acid anhydrides, isocyanates and chromium compounds are known to be both respiratory and skin sensitisers, capable of causing allergic asthma, allergic contact dermatitis, or both. The risk of respiratory versus skin sensitisation may depend on the particular substance, as well as its physical state, route of contact, method of use, and the individual worker.

Substances that are considered to have potential for sensitisation are identified in the list of Table of Workplace Exposure Standards with a <sup>(sen)</sup> notation.

## 10. SIMPLE ASPHYXIANTS

Some gases and vapours, when they are present in the air in significant concentrations, behave as asphyxiants “simply” by reducing the concentration of airborne oxygen by dilution (rather than by causing major toxic actions within the body).

The oxygen content of air should be maintained at 19.5% - 23.5%<sup>(2011)</sup> by volume under normal atmospheric conditions to prevent asphyxiation from occurring.

Atmospheres that are deficient in oxygen do not provide adequate sensory warning of danger, and most simple asphyxiants are odourless. In some cases, death can occur in only a few minutes.

Some simple asphyxiants can also present an explosion hazard if present in high volumes. It is therefore essential that the presence, hazards and controls of simple asphyxiants are communicated to employees.

## 11. INHALABLE AND RESPIRABLE DUSTS

### 11.1 Inhalable Dust

Criteria defining inhalable mass fractions have been defined by the International Standards Organisation (ISO)<sup>(6)</sup>. The definitions describe collection efficiency curves that pass through the following points:

d	0	10	30	60	100	185	
% inhalable mass fraction	ISO	100	77.4	58.3	51.4	50.1	0

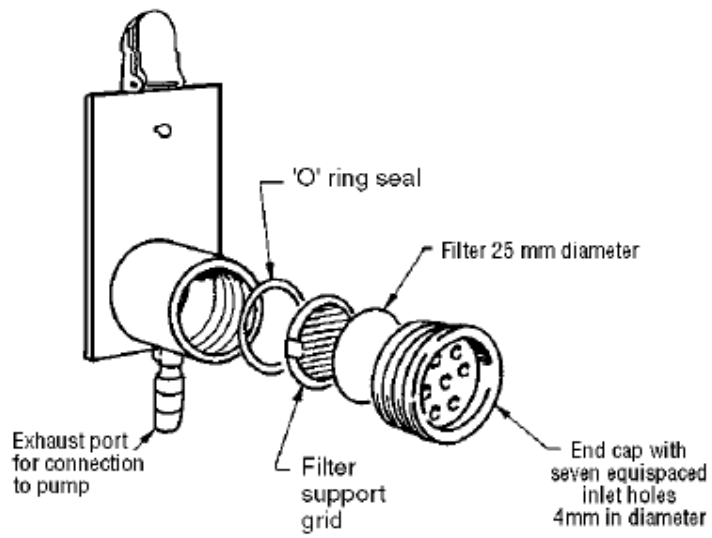
Where d is the equivalent aerodynamic diameter of the particle in  $\mu\text{m}$ .

**Table 3: Collection Efficiency Curves for Inhalable Dust**

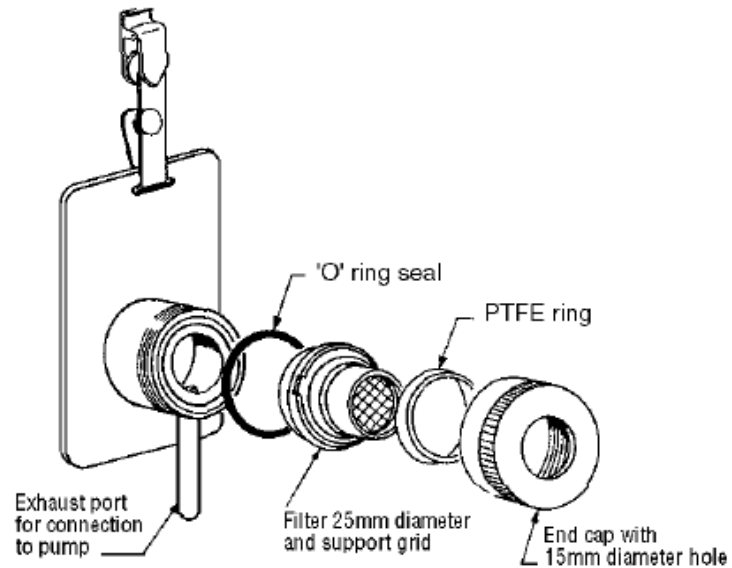
Different types of sampling devices that are specifically designed to conform to this specification may provide conflicting results if a significant proportion of the particles are larger than approximately  $30\mu\text{m}$ . At present there is no one acceptable procedure for obtaining a sample that accurately reflects the inhalable mass fraction (under various environmental conditions). However, for the purpose of these standards, the inhalable dust is to be collected according to the method set out in AS 3640: *Workplace Atmospheres – Method for Sampling and Gravimetric Determination of Inhalable Dust*<sup>(7)</sup>.

Two personal sampling heads are recommended: the United Kingdom Atomic Energy Authority (UKAEA) sampling head and the IOM inhalable dust sampling head developed by the UK Institute of Occupational Medicine, Edinburgh (see figures 1 and 2).

Personal air sampling pumps to be used with either head should be capable of maintaining a smooth flow of  $2 \pm 0.1$  litres/minute over the entire sampling period.



**Figure 1: Modified UKAEA Personal Sampling Head**



**Figure 2: IOM Inhalable Dust Sampling Head**

## 11.2 Respirable Dust

Respirable dust is the proportion of airborne particulate matter that penetrates to the unciliated airways when inhaled. Respirable dust samples are to be collected according to the method set out in the Standards Australia publication AS 2985: *Workplace Atmospheres – Method for Sampling and Gravimetric Determination of Respirable Dust*<sup>(8)</sup>.

This Standard refers to a sampling efficiency curve that passes through the following points:

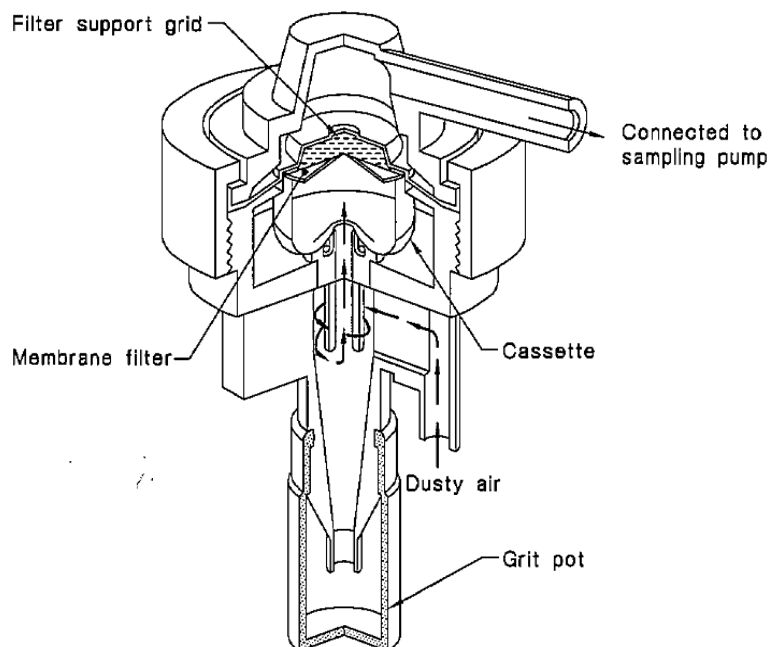
d	0	1	2	3	4	5	6	7
Respirability %	100	100	97	80	56	34	20	11

Where d is the equivalent aerodynamic diameter of the particle in  $\mu\text{m}$ .

**Table 4: Collection Efficiency Curve for Respirable Dust**

This fraction is further described in ISO 7708: *Air Quality – Particle Size Fraction Definitions for Health-Related Sampling*<sup>(7)</sup>.

The respirable dust fraction is to be collected with a device that is capable of collecting a sample that conforms to the aforementioned curve. One system is a miniature cyclone (see figure 3), with a pump that can maintain a smoothed flow of  $2.2 \pm 0.1$  litres/minute over the entire sampling period.



**Figure 3: Respirable Dust Sampler with Cyclone Elutriator**

## 12. RUBBER FUME AND RUBBER PROCESS DUST

The standards adopted for rubber process dust and rubber fume are those set by the UK Health and Safety Executive<sup>(9)</sup>.

**Rubber process dust** refers to dust that is generated during the manufacture of goods using natural rubber or synthetic elastomers. Excluded from the definition are substances for which a specific WES has been assigned. Unless information to the contrary is available, these substances should be considered to be additive to rubber process dust and the method for assessing mixed exposures should be applied. A personal inhalable dust sample is collected for comparison against the standard of  $6\text{mg}/\text{m}^3$  for rubber process dust.

**Rubber fume** refers to any fume that is evolved during the blending, milling and curing of natural rubbers or synthetic elastomers. The limit of  $0.6\text{mg}/\text{m}^3$  relates to the cyclohexane soluble material determined by the method: *Rubber Fume in Air, Measured as Total Particulates and Cyclohexane Soluble Material*<sup>(10)</sup>.

### 13. CARBON MONOXIDE (CO)

Exposure to carbon monoxide should be controlled to maintain a carboxyhaemoglobin (COHb) level below 3.5% (the Biological Exposure Index for CO). Under most conditions, this will be achieved if the average level over an eight-hour day does not exceed 25ppm, but there is also a need to control brief periods of high CO exposure. The following guidelines on short-term exposures are recommended:

#### Short-term Excursions for CO Exposure

Concentration (ppm)	Exposure Period
200ppm	15 minutes
100ppm	30 minutes
50ppm	60 minutes

**Table 5: Exposure Periods for Varying Concentrations of Carbon Monoxide**

- The CO level should not exceed 400ppm at any time during the day (Ceiling value).
- The sum of the exposure periods during the day at a particular level should not (in total) exceed the period indicated.



# Table of Workplace Exposure Standards

## REFERENCE KEY FOR TABLE OF WORKPLACE EXPOSURE STANDARDS

Key	Description
CAS #	CAS Number, a unique numbering identifier is assigned by the Chemical Abstracts Service Registry to each individual chemical.
ppm	Parts of vapour or gas per million of contaminated air by volume at 25°C and 760 torr.
mg/m <sup>3</sup>	Milligrams of substance per cubic metre of air.
(a)	The value for inhalable dust containing no asbestos and less than 1% free silica.
(b)	Fibres not less than 5µm and not more than 100µm in length, less than 3µm in width and with a length to width ratio of no less than 3:1.
(c)	Lint-free dust as measured by the vertical elutriator cotton-dust sampler described in the <i>Transactions of the National Conference on Cotton Dust</i> , p.33, by J.R. Lynch (May 2, 1970).
(d)	A range of airborne contaminants are associated with gas and arc welding. The type of metal being welded, the electrode employed and the welding process will all influence the composition and amount of fume. Gaseous products such as oxides of nitrogen, carbon monoxide and ozone may also be produced. In the absence of toxic elements such as chromium, and where conditions do not support the generation of toxic gases, the fume concentration inside the welder's helmet should not exceed 5mg/m <sup>3</sup> .
(e)	Sampled by a method that does not collect vapour.
(f)	Polychlorinated Biphenyls (PCBs) are Persistent Organic Pollutants (POPs), which will be phased out in New Zealand by 2016. They are banned from importation, production and use. Exemptions allow for the storage of PCBs for a limited time and for small-scale research/laboratory use. An <a href="#">Approved Management Plan</a> is required to store and use PCBs. Further information is available from the Ministry of Health.
(g)	Biological monitoring recommended.
6.7A	Confirmed carcinogen
6.7B	Suspected carcinogen
(2010)	September 2010 change
(D2010)	December 2010 change
<b>(2011)</b>	<b>2011 correction</b>
(skin)	Skin absorption
(sen)	Sensitiser
(bio)	Exposure can also be estimated by biological monitoring.

<b>A</b>		TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
Substance	CAS #				
Acetaldehyde <sup>6.7B</sup>	[75-07-0]	20		50	
Acetamide	[60-35-5]				
Acetic acid	[64-19-7]	10	25	15	37
<b>Acetic anhydride<sup>(2011)</sup></b>	<b>[108-24-7]</b>	<b>Ceiling 5ppm (21 mg/m<sup>3</sup>)</b>			
Acetone <sup>(bio)</sup>	[67-64-1]	500	1,185	1,000	2,375
Acetone cyanohydrin	[75-86-5]				
Acetonitrile <sup>(skin)</sup>	[75-05-8]	40	67	60	101
<b>Acetophenone<sup>(2011)</sup></b>	<b>[98-86-2]</b>				
Acetylene	[74-86-2]	Simple asphyxiant – may present an explosion hazard			
Acetylene dichloride (see 1,2-Dichloroethylene)					
Acetylene tetrabromide	[79-27-6]	1	14		
Acetylsalicylic acid	[50-78-2]		5		
Acrolein	[107-02-8]	0.1	0.23		
Acrylamide <sup>(skin)</sup> <sup>6.7A</sup>	[79-06-1]		0.03		
Acrylic acid <sup>(skin)</sup>	[79-10-7]	2	5.9		
Acrylic acid polymer	[9003-01-4]				
Acrylonitrile <sup>(skin)</sup> <sup>6.7A</sup>	[107-13-1]	2	4.3		
Adipic acid	[124-04-9]				
Adiponitrile	[111-69-3]				
Aflatoxins					
Allyl alcohol	[107-18-6]	2	4.8	4	9.5
Allyl chloride <sup>6.7B</sup>	[107-05-1]	1	3	2	6.0
Allyl glycidyl ether (AGE)	[106-92-3]	5	23	10	47
<b>Allyl propyl disulfide<sup>(2011)</sup></b>	<b>[2179-59-1]</b>	<b>2</b>	<b>12</b>	<b>3</b>	<b>18</b>
α Alumina (see Aluminium oxide )					

<b>A</b>		<b>TWA</b>		<b>STEL</b>		
		<b>Substance</b>	<b>CAS #</b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>
	<b>Aluminium, as Al</b>	[7429-90-5]				
	Metal dust			10		
	Pyro powders			5		
	Welding fumes			5		
	Soluble salts			5		
	Alkyls (not otherwise classified)			2		
	Aluminium oxide	[1344-28-1]		10 <sup>(a)</sup>		
	4-Aminodiphenyl <sup>6.7A</sup>	[92-67-1]				
	2-Aminoethanol (see Ethanolamine)					
	2-Aminopyridine	[504-29-0]	0.5	2.0		
	3-Amino-1,2,4-triazole (see Amitrole)					
	Amitrole	[61-82-5]		0.2		
	Ammonia, Anhydrous	[7664-41-7]	25	17	35	24
	Ammonium chloride fume	[12125-02-9]		10		20
	Ammonium perfluorooctanoate <sub>(skin)</sub> <sup>6.7B</sup>	[3825-26-1]		0.1		
	Ammonium sulphamate	[7773-06-0]		10		
	Amosite (see Asbestos)					
	n-Amyl acetate	[628-63-7]	100	532		
	sec-Amyl acetate	[626-38-0]	125	665		
	Aniline & homologues <sub>(skin)</sub> <sup>6.7B</sup>	[62-53-3]	1	4		
	Anisidine (o-, p- isomers) <sub>(skin)</sub> <sup>6.7B</sup>	[29191-52-4]	0.1	0.50		
	Antimony & compounds, as Sb	[7440-36-0]		0.5		

<b>A</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Antimony hydride (see Stibine)					
	Antimony trioxide <sup>6.7B</sup>	[1309-64-4]		0.5		
	p-Aramid	[24938-64-5]				
	Argon	[7440-37-1]	Simple asphyxiant			
	Arsenic & soluble compounds, as As <sup>6.7A</sup>	[7440-38-2]		0.05		
	Arsine	[7784-42-1]	0.05	0.16		
	<b>Asbestos</b> <sup>(b)</sup> confirmed carcinogen	[1332-21-4]	<p>1) An average concentration of any 4-hour period of one fibre per millilitre of air; and</p> <p>2) An average concentration over any 10-minute period of 6 fibres per millilitre of air.</p> <p>1) An average concentration over any 4-hour period of 0.1 fibres per millilitre of air; and</p> <p>2) An average concentration over any 10-minute period of 0.6 fibres per millilitre of air.</p> <p>The maximum allowable concentrations of asbestos are established by the <i>New Zealand Gazette</i> notice and are liable to alterations.</p>			
	Chrysotile	[12001-29-5]				
	Fibrous actinolite					
	Fibrous anthophyllite					
	Fibrous tremolite	[77536-68-6]				
	Amosite Crocidolite	[12172-73-5] [12001-28-4]				
	<b>Asphalt (petroleum) fumes</b> <sup>(2011)</sup>	[8052-42-4]		5		
	Aspirin (see Acetylsalicylic acid)					
	Atrazine	[1912-24-9]		5		
	Azinphos-methyl <sub>(skin)</sub>	[86-50-0]		0.2		
	Azodicarbonamide <sub>(sen)</sub>	[123-77-3]				

<b>B</b>	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
Barium, soluble compounds, as Ba	[7440-39-3]		0.5		
<b>Barium sulphate</b> <sup>(2011)</sup>	<b>[7727-43-7]</b>		<b>10<sup>(a)</sup></b>		
<b>Benomyl</b> <sup>(2011)</sup>	<b>[17804-35-2]</b>	<b>0.84</b>	<b>10</b>		
Benz(a)anthracene 6.7A	[56-55-3]				
Benzene (skin) 6.7A (2010)	[71-43-2]	1		2.5	
Benzidine (skin) 6.7A	[92-87-5]				
Benzo(b)fluoroethane 6.7A	[205-99-2]				
p-Benzoquinone (see Quinone)					
Benzoyl peroxide	[94-36-0]		5		
Benzo(a)pyrene 6.7A	[50-32-8]				
Benzotrichloride (skin) 6.7A	[98-07-7]				
Benzoyl chloride	[98-88-4]				
Benzyl acetate	[140-11-4]				
Benzyl butyl phthalate	[85-68-7]		5		
Benzyl chloride 6.7A	[100-44-7]	1	5.2		
Beryllium and compounds, as Be 6.7A	[7440-41-7]		0.002		
Biphenyl	[92-52-4]	0.2	1.3		
Bis[2-dimethylaminoethyl] ether (DMAEE)	[3033-62-3]				
<b>Borates, tetra, sodium salts</b>					
Anhydrous			1		
Decahydrate	[1303-96-4]		5		
Pentahydrate			1		
Boric Acid	[10043-35-3]				

<b>B</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Boron oxide	[1303-86-2]		10		
	Boron tribromide	[10294-33-4]	Ceiling 1ppm (10mg/m <sup>3</sup> )			
	Boron trifluoride	[7637-07-2]	Ceiling 1ppm (2.8mg/m <sup>3</sup> )			
	Bromacil <sub>6.7B</sub>	[314-40-9]	1	11		
	Bromine	[7726-95-6]	0.1	0.66	0.3	2
	Bromine pentafluoride	[7789-30-2]	0.1	0.72		
	Bromochloromethane (see Chlorobromomethane)					
	Bromoform <sub>(skin)</sub>	[75-25-2]	0.5	5.2		
	1,3-Butadiene <sub>6.7A</sub>	[106-99-0]	10	22		
	Butane	[106-97-8]	800	1,900		
	Butanethiol (see Butyl mercaptan)					
	2-Butanone (see Methyl ethyl ketone)					
	2-Butoxyethanol <sub>(skin)</sub>	[111-76-2]	25	121		
	2-Butoxyethyl acetate	[112-07-2]				
	n-Butyl acetate	[123-86-4]	150	713	200	950
	sec-Butyl acetate	[105-46-4]	200	950		
	tert-Butyl acetate	[540-88-5]	200	950		
	Butyl acrylate <sub>(sen)</sub>	[141-32-2]	10	52		
	n-Butyl alcohol <sub>(skin)</sub>	[71-36-3]	Ceiling 50ppm (150mg/m <sup>3</sup> )			
	sec-Butyl alcohol	[78-92-2]	100	303		
	tert-Butyl alcohol	[75-65-0]	100	303	150	455
	sec-Butylamine	[13952-84-6]				
	tert-Butylamine	[75-64-9]				

<b>B</b>	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
Butylated hydroxytoluene (see 2,6-Di-tert-butyl-p-cresol)					
n-Butyl glycidyl ether (BGE) (sen)	[2426-08-6]	25	133		
Butyl glycol ether (see 2- Butoxyethanol)					
n-Butyl lactate	[138-22-7]	5	30		
<b>Butyl mercaptan</b> <sup>(2011)</sup>	<b>[109-79-5]</b>	<b>0.5</b>	<b>1.8</b>		
o-sec-Butylphenol <sub>(skin)</sub>	[89-72-5]	5	31		
p-tert-Butyltoluene	[98-51-1]	10	61	20	121
n-Butyronitrile	[109-74-0]				

<b>C</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Cadmium & compounds, as Cd <sub>6.7A (bio)</sub>	[7440-43-9]		0.01 inhalable dust 0.002 respirable dust		
	<b>Calcium carbonate</b> <sup>(2011)</sup>	<b>[471-34-1]</b>		<b>10<sup>(a)</sup></b>		
	Calcium chromate, as Cr <sub>6.7A</sub>	[13765-19-0]		0.001		
	Calcium cyanamide	[156-62-7]		0.5		
	Calcium hydroxide	[1305-62-0]		5		
	Calcium hypochlorite	[7778-54-3]				
	Calcium oxide	[1305-78-8]		2		
	Calcium silicate	[1344-95-2]		10 <sup>(a)</sup>		
	Calcium sulphate	[7778-18-9]		10 <sup>(a)</sup>		
	Camphor, synthetic	[76-22-2]	2	12	3	19
	Caprolactam (dust vapour)	[105-60-2]	5	1 23	10	3 46
	Captafol <sub>(skin)</sub>	[2425-06-1]		0.1		
	Captan <sub>6.7B</sub>	[133-06-2]		5		
	Carbaryl	[63-25-2]		5		
	Carbofuran	[1563-66-2]		0.1		
	<b>Carbon black</b> <sup>(2011)</sup> <sub>6.7B</sub>	<b>[1333-86-4]</b>		<b>3</b>		
	Carbon dioxide	[124-38-9]	5,000	9,000	30,000	54,000
	Carbon disulphide <sub>(skin)</sub>	[75-15-0]	10	31		
	Carbon monoxide <sub>(bio)</sub> See section on carbon monoxide	[630-08-0]	25ppm Ceiling 400ppm		200ppm 15 min 100ppm 30 min 50ppm 60 min	
	Carbon tetrabromide	[558-13-4]	0.1	1.4		
	Carbon tetrachloride <sub>(skin)</sub> <sub>6.7B</sub>	[56-23-5]	0.1	0.63		

C Substance	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
Carbonyl chloride (see Phosgene)					
Carbonyl fluoride	[353-50-4]	2	5.4	5	13
Catechol <sub>(skin)</sub>	[120-80-9]	5	23		
Cellulose (paper fibre)	[9004-34-6]		10 <sup>(a)</sup>		
Cement (see Portland cement)					
Cetylmercaptan	[2917-26-2]				
Chlorinated diphenyl oxide	[55720-99-5]		0.5		
Chlorine	[7782-50-5]	0.5	1.5	1	2.9
Chlorine dioxide	[10049-04-4]	0.1	0.28		
Chloroacetaldehyde	[107-20-0]	Ceiling 1ppm (3.2 mg/m <sup>3</sup> )			
Chloroacetone <sub>(skin)</sub>	[78-95-5]	Ceiling 1ppm (3.8 mg/m <sup>3</sup> )			
α-Chloroacetophenone	[532-27-4]	0.05	0.32		
Chloroacetyl chloride <sub>(skin)</sub>	[79-04-9]	0.05	0.23	0.15	0.69
Chlorobenzene	[108-90-7]	10	46		
o-Chlorobenzylidene malononitrile <sub>(skin)</sub>	[2698-41-1]	Ceiling 0.05ppm (0.39 mg/m <sup>3</sup> )			
Chlorobromomethane	[74-97-5]	200	1,060		
2-Chloro-1,3-butadiene (see β-Chloroprene )					
1-Chloro-1,1-difluoroethane	[75-68-3]				
Chlorodifluoromethane	[75-45-6]	1,000	3,540		
1-Chloro-2,3-epoxy propane (see Epichlorohydrin)					

C Substance	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
2-Chloroethanol (see Ethylene chlorohydrin)					
Chloroethylene (see Vinyl chloride)					
Chloroform <small>(skin)</small> 6.7B	[67-66-3]	2	9.9		
bis(Chloromethyl) ether 6.7A	[542-88-1]	0.001	0.0047		
Chloromethyl methyl ether 6.7A	[107-30-2]				
Chloropentafluoroethane	[76-15-3]	1,000	6,320		
Chloropicrin	[76-06-2]	0.1	0.67		
β-Chloroprene <small>(skin)</small>	[126-99-8]	10	36		
2-Chloropropionic acid <small>(skin)</small>	[598-78-7]	0.1	0.44		
o-Chlorostyrene	[2039-87-4]	50	283	75	425
Chlorosulphonic acid	[7790-94-5]		1		
o-Chlorotoluene	[95-49-8]	50	259		
Chlorotrifluoromethane	[75-72-9]				
Chloropyrifos <small>(skin)</small>	[2921-88-2]		0.2		
<b>Chromite ore processing (Chromate)<sup>(2011)</sup>, as Cr</b> 6.7A			<b>0.05</b>		
Chromium metal	[7440-47-3]		0.5		
Chromium (II) compounds, as Cr			0.5		
Chromium (III) compounds, as Cr			0.5		

C Substance	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
<b>Chromium (VI) compounds, as Cr<sub>(bio)</sub></b> <b>Water soluble<sub>(sen)</sub></b> <b>Water insoluble<sup>(2011)</sup><sub>(sen)</sub></b> 6.7A			0.05 0.05		
Chromyl chloride	[14977-61-8]	0.025	0.16		
Chrysene 6.7A	[218-01-9]				
Chrysotile (see Asbestos)					
Clopidol	[2971-90-6]		10		
Coal dust			3mg/m3 Respirable dust  0.15mg/m3 Respirable quartz		
Coal tar pitch volatiles, as benzene solubles 6.7A	[65996-93-2]		0.2		
Cobalt metal dust & fume, as Co <sub>(bio)</sub> 6.7B	[7440-48-4]		0.05		
Cobalt carbonyl, as Co <sub>(sen)</sub>	[10210-68-1]		0.1		
Copper fume Dusts & mists, as Cu	[7440-50-8]		0.2 1		
Cotton dust, raw			0.2 <sup>(c)</sup>		
Cresol, all isomers <sub>(skin)</sub>	[1319-77-3]	5	22		
Cristobalite (see Silica-Crystalline)					
Crocidolite (see Asbestos)					
Crotonaldehyde <sub>(skin)</sub> 6.7B	[4170-30-3]	2	5.7		
Cumene <sub>(skin)</sub>	[98-82-8]	25	125	75	375
Cyanamide	[420-04-2]		2		

<b>C</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Cyanides, as CN <sub>(skin)</sub>	[151-50-8]; [143-33-9]		5		
	Cyanogen	[460-19-5]	10	21		
	Cyanogen chloride	[506-77-4]	Ceiling 0.3pppm (0.75 mg/m <sup>3</sup> )			
	Cyclohexane	[110-82-7]	100	350	300	1050
	Cyclohexanol <sub>(skin)</sub>	[108-93-0]	50	206		
	Cyclohexanone <sub>(skin)</sub>	[108-94-1]	25	100		
	Cyclohexene	[110-83-8]	300	1,010		
	Cyclohexylamine	[108-91-8]	10	41		
	Cyclohexylmercaptan	[1569-69-3]				
	<b>Cyclonite<sup>(2011)</sup></b> <sub>(skin)</sub>	<b>[121-82-4]</b>		<b>1.5</b>		
	Cyclopentadiene	[542-92-7]	75	203		
	Cyclopentane	[287-92-3]	600	1,720		

<b>D</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	2,4-D	[94-75-7]		10		
	Diacetone alcohol	[123-42-2]	50	238		
	Diallyl phthalate	[131-17-9]		5		
	1,2-Diaminoethane (see Ethylenediamine)					
	Diatomaceous earth (see Silica-Amorphous)					
	Diazinon <i>(skin)</i>	[333-41-5]		0.1		
	Diborane	[19287-45-7]	0.1	0.11		
	1,2-Dibromomethane (see Ethylene dibromide)					
	2-N-Dibutylaminoethanol <i>(skin)</i>	[102-81-8]	2	14		
	Dibutyl phenyl phosphate <i>(skin)</i>	[2528-36-1]	0.3	3.5		
	Dibutyl phosphate	[107-66-4]	1	8.6	2	17
	Dibutyl phthalate	[84-74-2]		5		
	Dichloroacetylene 6.7B	[7572-29-4]	Ceiling 0.1ppm (0.39mg/m <sup>3</sup> )			
	o-Dichlorobenzene <i>(skin)</i>	[95-50-1]	Ceiling 50pppm (301mg/m <sup>3</sup> )			
	p-Dichlorobenzene 6.7B	[106-46-7]	25	153	50	306
	3,3-Dichlorobenzidine <i>(skin)</i> 6.7B	[91-94-1]				
	1,4-Dichloro-2-butene <i>(skin)</i> 6.7A	[764-41-1]				
	Dichlorodifluoromethane	[75-71-8]	1,000	4,950		
	1,3-Dichloro-5,5-dimethyl hydantoin	[118-52-5]		0.2		0.4
	1,1-Dichloroethane	[75-34-3]	200	810	250	1,010

<b>D</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	1,2-Dichloroethane (see Ethylene dichloride)					
	1,1-Dichloroethylene (see Vinylidene chloride)					
	1,2-Dichloroethylene	[540-59-0]	200	793		
	Dichloroethyl ether <small>(skin)</small>	[111-44-4]	5	29	10	58
	Dichlorofluoromethane	[75-43-4]	10	42		
	Dichloromethane (see Methylene chloride)					
	1,1-Dichloro-1-nitroethane	[594-72-9]	2	12		
	1,2-Dichloropropane (see Propylene dichloride)					
	Dichloropropene <small>(skin)</small>	[542-75-6]	1	4.5		
	2,2-Dichloropropionic acid	[75-99-0]	1	5.8		
	Dichlorotetrafluoroethane	[76-14-2]	1,000	6,990		
	Dichlorvos <small>(skin)</small>	[62-73-7]	0.1	0.90		
	Dicrotophos <small>(skin)</small>	[141-66-2]		0.25		
	Dicyclohexyl phthalate	[84-61-7]		5		
	Dicyclopentadiene	[77-73-6]	5	27		
	Dicyclopentadienyl iron	[102-54-5]		5		
	Diethanolamine <small>(skin)</small>	[111-42-2]	3	13		
	Diethylamine <small>(skin)</small>	[109-89-7]	10	30	25	75
	2-Diethylaminoethanol <small>(skin)</small>	[100-37-8]	10	48		
	Diethylene glycol	[111-46-6]	23	101		
	Diethylene glycol dimethyl ether	[111-96-6]				

<b>D</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Diethylene glycol monobutyl ether	[112-34-5]				
	Diethylene glycol monobutyl ether acetate	[124-17-4]				
	<b>Diethylene glycol monomethyl ether<sup>(2011)</sup></b>	<b>[111-77-3]</b>				
	Diethylene triamine (skin)	[111-40-0]	1	4.2		
	Diethyl ether (see Ethyl ether)					
	Di(2-ethylhexyl)phthalate (see Di-sec-octyl phthalate)					
	Diethyl ketone	[96-22-0]	200	705		
	Diethyl phthalate	[84-66-2]		5		
	Diethyl sulphate (skin)	[64-67-5]	0.05	0.32		
	Difluorodibromomethane	[75-61-6]	100	858		
	Diglycidyl ether (DGE)	[2238-07-5]	0.1	0.53		
	Dihydroxybenzene (see Hydroquinone)					
	Diisobutyl ketone	[108-83-8]	25	145		
	Diisobutyl phthalate	[84-69-5]		5		
	Diisodecyl phthalate	[26761-40-0]		5		
	Diisononyl phthalate	[28553-12-0]		5		
	Diisooctyl phthalate	[27554-26-3]		5		
	Diisopropylamine	[108-18-9]	5	21		
	Dimethoxymethane (see Methylal)					
	Dimethyl acetamide (skin)	[127-19-5]	10	36		
	Dimethylamine	[124-40-3]	10	18		
	Dimethylaminoethanol	[108-01-0]	2	7.4	6	22

<b>D</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
		<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
Dimethylaminobenzene (see Xylidine)					
N,N-Dimethylaniline (skin)	[121-69-7]	5	25	10	50
Dimethylbenzene (see Xylene)					
Dimethyl carbamoyl chloride 6.7A	[79-44-7]				
Dimethyl-1,2-dibromo-2,2-dichloroethyl phosphate (see Naled)					
Dimethylether	[115-10-6]	400	766	500	958
N,N-Dimethylethylamine	[598-56-1]	10	30	15	46
Dimethylformamide (skin)	[68-12-2]	10	30		
2,6-Dimethyl-4-heptanone (see Diisobutyl ketone)					
1,1-Dimethylhydrazine (skin) 6.7B	[57-14-7]	0.01	0.025		
Dimethylnitrosoamine (see N-Nitrosodimethylamine)					
Dimethylphthalate	[131-11-3]		5		
Dimethyl sulphate (skin) 6.7A	[77-78-1]	0.05	0.26		
Dimethyl sulphoxide	[67-68-5]				
Dinitolmide	[148-01-6]		5		
Dinitrobenzene, all isomers (skin)	[528-29-0]; [99-65-0]; [100-25-4]	0.15	1.0		
Dinitro-o-cresol (skin)	[534-52-1]		0.2		
3,5-Dinitro-o-toluamide (see Dinitolmide)					
2,4-Dinitrotoluene	[121-14-2]				
3,5-Dinitrotoluene	[618-85-9]				
Dinonyl phthalate	[84-76-4]		5		

<b>D</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Dioxane (skin) 6.7A	[123-91-1]	25	90		
	Diphenyl (see Biphenyl)					
	Dipenylamine	[122-39-4]		10		
	Diphenylmethane diisocyanate (see Isocyanates)					
	Dipropylene glycol methyl ether (skin)	[34590-94-8]	100	606	150	909
	Dipropyl ketone	[123-19-3]	50	233		
	Diquat	[2764-72-9]		0.5		
	Diquat dibromide	[85-00-7]		0.5		
	Di-sec-octyl phthalate	[117-81-7]		5		10
	Disulfiram	[97-77-8]		2		
	Disolfoton	[298-04-4]		0.1		
	2,6-Di-tert-butyl-p-cresol	[128-37-0]		10		
	Diuron	[330-54-1]		10		
	Divinyl benzene	[1321-74-0]	10	53		

<b>E</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Emery	[1302-74-5]		10 <sup>(a)</sup>		
	Enzymes (see Subtilins)					
	Epichlorohydrin <small>(skin) 6.7A</small>	[106-89-8]	0.5	1.9	1.5	5.8
	1,2-Epoxypropane (see Propylene oxide)					
	2,3-Epoxy-1-propanol (see Glycidol)					
	Ethane	[74-84-0]	Simple asphyxiant – may present an explosion hazard			
	Ethanthiol (see Ethyl mercaptan)					
	Ethanol (see Ethyl alcohol)					
	Ethanolamine	[141-43-5]	3	7.5	6	15
	Ethion <small>(skin)</small>	[563-12-2]		0.4		
	2-Ethoxyethanol <small>(skin) (bio)</small>	[110-80-5]	5	18		
	2-Ethoxyethyl acetate (EGEEA) <small>(skin), (bio)</small>	[111-15-9]	5	27		
	Ethyl acetate	[141-78-6]	200	720		
	Ethyl acrylate <small>(sen)</small>	[140-88-5]	Ceiling 5ppm (20mg/m <sup>3</sup> )			
	Ethyl alcohol	[64-17-5]	1,000	1,880		
	Ethylamine <small>(skin)</small>	[75-04-7]	10	18		
	Ethyl amyl ketone	[541-85-5]	25	131		
	Ethyl benzene	[100-41-4]	100	434	125	543
	Ethyl bromide <small>(skin) 6.7B</small>	[74-96-4]	5	22		
	Ethyl tert-butyl ether	[637-92-3]				
	Ethyl butyl ketone	[106-35-4]	50	234		
	Ethyl chloride <small>(skin) 6.7B</small>	[75-00-3]	1,000	2,640		

<b>E</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Ethyl chloroformate	[541-41-3]				
	Ethyl cyanocrylate	[7085-85-0]				
	Ethylene	[74-85-1]	Simple asphyxiant			
	Ethylene chlorohydrin (skin)	[107-07-3]	Ceiling 1ppm (3.3mg/m <sup>3</sup> )			
	Ethylenediamine (skin), (sen)	[107-15-3]	10	25		
	Ethylene dibromide (skin) 6.7A	[106-93-4]	0.5	3.9		
	Ethylene dichloride (skin)	[107-06-2]	5	21		
	Ethylene glycol (vapour and mist)	[107-21-1]	Ceiling 50ppm (127mg/m <sup>3</sup> )			
	Ethylene glycol dinitrate (skin)	[628-96-6]	0.05	0.31		
	Ethylene glycol isopropylether acetate	[19234-20-9]				
	Ethylene glycol methyl ether acetate (see 2-Methoxyethyl acetate)					
	Ethylene oxide 6.7A	[75-21-8]	1	1.8		
	Ethyleneimine (skin) 6.7B	[151-56-4]	0.5	0.88		
	Ethyl ether	[60-29-7]	400	1,210	500	1,520
	Ethyl formate	[109-94-4]	100	303		
	2-Ethylhexyl chloroformate	[24468-13-1]				
	Ethylidene chloride (see 1,1- Dichloroethane)					
	Ethylidene norborene	[16219-75-3]	Ceiling 5ppm (25mg/m <sup>3</sup> )			
	Ethyl mercaptan	[75-08-1]	0.5	1.3		
	Ethyl methacrylate	[97-63-2]				
	N-Ethylmorpholine (skin)	[100-74-3]	5	24		
	Ethyl silicate	[78-10-4]	10	85		
	Ethylene glycol isopropyl ether	[109-59-1]	25	106		

<b>F</b>	Substance	CAS #	TWA		STEL	
			ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
	<b>Fenamiphos<sup>(2011)</sup> (skin)</b>	<b>[22224-92-6]</b>		<b>0.1</b>		
	Fenthion (skin)	[55-38-9]		0.2		
	Ferbam	[14484-64-1]		10		
	Ferrovandium dust	[12604-58-9]		1		
	Fibrous glass dust (see Synthetic mineral fibres)					
	Flour dust					
	Fluorides, as F (bio)			2.5		
	Fluorine	[7782-41-4]	1	1.6	2	3.1
	Fluorotrichloromethane (see Trichlorofluoromethane)					
	Formaldehyde (sen) 6.7A (D2010)	[50-00-0]	0.5ppm (8 hour shift) 0.33ppm (12 hour shift) <sup>iv</sup> Ceiling 1ppm			
	Formamide (skin)	[75-12-7]	10	18		
	Formic acid	[64-18-6]	5	9.4	10	19
	Furfural (skin) 6.7B	[98-01-1]	2	7.9		
	Furfuryl alcohol (skin)	[98-00-0]	10	40	15	60

<sup>iv</sup> Implementation of the eight and 12-hour shift WES will be staged over a one-year period commencing from 13<sup>th</sup> December 2010.

<b>G</b>		TWA		STEL		
		CAS #	ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
	Gasoline (see Petrol)					
	Glass, fibrous or dust (see Synthetic mineral fibres)					
	Glutaraldehyde <small>(sen)</small>	[111-30-8]			0.05	
	Glycerin (mist)	[56-81-5]		10 <sup>(a)</sup>		
	Glycidol <small>6,7B</small>	[556-52-5]	25	76		
	Glycidyl methacrylate	[106-91-2]				
	Glycol monoethyl ester (see 2-Ethoxyethanol)					
	Grain dust (oat, wheat, barley)			4		
	<b>Graphite, all forms except graphite fibres<sup>(2011)</sup></b>	<b>[7782-42-5]</b>		<b>3 (Respirable dust containing &lt;1% free silica)</b>		
	Gypsum (see Calcium sulphate)					

<b>H</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Halothane	[151-67-7]	0.5			
	Helium	[7440-59-7]	Simple asphyxiant			
	Heptane (n-Heptane)	[142-82-5]	400	1,640	500	2,050
	2-Heptanone (see Methyl n-amyl ketone)					
	3-Heptanone (see Ethyl butyl ketone)					
	Hexachlorobenzene (skin) 6.7B	[118-74-1]				
	Hexachlorocyclopentadiene	[77-47-4]	0.01	0.11		
	Hexachloroethane (skin) 6.7B	[67-72-1]	1	9.7		
	Hexafluoroacetone (skin)	[684-16-2]	0.1	0.68		
	Hexamethylene diisocyanate (see Isocyanates)					
	Hexamethyl phosphoramidate (skin) 6.7B	[680-31-9]				
	Hexane (n-Hexane) (bio) Other isomers	[110-54-3]	20 500	72 1,760	1,000	3,500
	2-Hexanone (see Methyl n-butyl ketone )					
	Hexone (see Methyl isobutyl ketone)					
	1,6-Hexanediamine	[124-09-4]				
	1-Hexene	[592-41-6]				
	sec-Hexyl acetate	[108-84-9]	50	295		
	Hexylene glycol	[107-41-5]	Ceiling 25ppm (121mg/m <sup>3</sup> )			
	Hydrazine (skin) 6.7B	[302-01-2]	0.01	0.013		
	Hydrogen	[1333-74-0]	Simple asphyxiant – may present an explosion hazard			
	Hydrogenated terphenyls	[61788-32-7]	0.5	4.9		

<b>H</b>		<b>TWA</b>		<b>STEL</b>	
		<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	<b>Substance</b>	<b>CAS #</b>			
	Hydrogen bromide	[10035-10-6]	Ceiling 3ppm (9.9mg/m <sup>3</sup> )		
	Hydrogen chloride	[7647-01-0]	Ceiling 5ppm (7.5mg/m <sup>3</sup> )		
	Hydrogen cyanide <i>(skin)</i>	[74-90-8]	Ceiling 10ppm (11mg/m <sup>3</sup> )		
	Hydrogen fluoride, as F	[7664-39-3]	Ceiling 3ppm (2.6mg/m <sup>3</sup> )		
	Hydrogen peroxide <sub>6.7B</sub>	[7722-84-1]	1	1.4	
	Hydrogen sulphide	[7783-06-4]	10	14	15 21
	Hydroquinone <sub>6.7B</sub>	[123-31-9]		2	
	4-Hydroxy-4-methyl-2-pentanone (see Diacetone alcohol)				
	2-Hydroxyethyl acrylate	[818-61-1]			
	2-Hydroxyethyl methacrylate	[868-77-9]			
	2-Hydroxypropyl acrylate <i>(skin)</i>	[999-61-1]	0.5	2.8	

Substance	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
Idomethane <sub>(skin)</sub>	[74-88-4]	2	12		
Indene	[95-13-6]	10	48		
Indium & compounds, as In	[7440-74-6]		0.1		
Iodine	[7553-56-2]	Ceiling 0.1ppm (1mg/m <sup>3</sup> )			
Iodoform	[75-47-8]	0.6	10		
Iron oxide dust and fume (Fe <sub>2</sub> O <sub>3</sub> ), as Fe	[1309-37-1]		5 <sup>(d)</sup>		
Iron pentacarbonyl, as Fe	[13463-40-6]	0.1	0.23	0.2	0.45
Iron salts, soluble, as Fe			1		
Isoamyl acetate	[123-92-2]	100	532		
Isoamyl alcohol	[123-51-3]	100	361	125	452
Isobutane	[75-28-5]				
Isobutyl acetate	[110-19-0]	150	713		
Isobutyl alcohol	[78-83-1]	50	152		
Isobutylamine	[78-81-9]				
Isobutyl methacrylate	[97-86-9]				
Isocyanates, all, (as -NCO) <sub>(sen)</sub>		0.02		0.07	
		Note: These values apply to all isocyanates, including prepolymers, present in the workplace air as vapours, mist or dust.			
Isooctyl alcohol <sub>(skin)</sub>	[26952-21-6]	50	266		
Isophorone <sub>6,7B</sub>	[78-59-1]	Ceiling 5ppm (28mg/m <sup>3</sup> )			
Isophorone diisocyanate <sub>(skin)</sub> (see Isocyanates)					

Substance	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
Isopropyl acetate	[108-21-4]	250	1,040	310	1,290
Isopropyl alcohol	[67-63-0]	400	983	500	1,230
Isopropylamine	[75-31-0]	5	12	10	24
Isopropyl ether	[108-20-3]	250	1,040	310	1,300
Isopropyl glycidyl ether (IGE)	[4016-14-2]	50	238	75	356

<b>K</b>		<b>TWA</b>		<b>STEL</b>	
		<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
Substance	CAS #				
Kaolin	[1332-58-7]	10mg/m <sup>3</sup> Inhalable dust; and 2mg/m <sup>3</sup> Respirable dust			
Kerosene	[8008-20-6]				
Ketene	[463-51-4]	0.5	0.86		

<b>L</b>		<b>TWA</b>		<b>STEL</b>	
		<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	<b>Substance</b>	<b>CAS #</b>			
	Lead, inorganic dusts & fumes, as Pb (bio) 6.7B	[7439-92-1]		0.1	
	Lead chromate, as Cr 6.7A	[7758-97-6]		0.05	
	Limestone (see Calcium carbonate)				
	Lindane (skin) 6.7B	[58-89-9]		0.1	
	Lithium hydride	[7580-67-8]		0.025	
	Lithium hydroxide	[1310-65-2]			1
	LPG (Liquefied petroleum gas)	[68476-85-7]	1,000	1,800	

M	Substance	CAS #	TWA		STEL	
			ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
	Magnesite	[546-93-0]		10		
	Magnesium oxide fume	[1309-48-4]		10		
	Malathion <sub>(skin)</sub>	[121-75-5]		10		
	Maleic anhydride <sub>(sen)</sub>	[108-31-6]	0.25	1.0		
	Man-made mineral fibres (see Synthetic mineral fibres)					
	Manganese dust & compounds, as Mn	[7439-96-5]		1		
	Fume, as Mn	[7439-95-5]		1		3
	Manganese cyclopentadienyl tricarbonyl, as Mn <sub>(skin)</sub>	[12079-65-1]		0.1		
	Marble (see Calcium carbonate)					
	MDI (see Isocyanates)					
	MEK (see Methyl ethyl ketone)					
	Mercury vapour (as Hg) <sub>(skin), (bio)</sub>	[7439-97-6]		0.025		
	Inorganic compounds (as Hg)			0.025		
	Alkyl compounds (as Hg)			0.01		
	Mesityl oxide	[141-79-7]	15	60	25	100
	Methacrylic acid	[79-41-4]	20	70		
	Methane	[74-82-8]	Simple asphyxiant – may present an explosion hazard			
	Methanethiol (see Methyl mercaptan)					
	Methanol (see Methyl alcohol)					
	Methomyl	[16752-77-5]		2.5		
	Methoxyacetic acid	[625-45-6]				
	Methoxychlor	[72-43-5]		10		
	2-Methoxyethanol <sub>(skin)</sub>	[109-86-4]	5	16		

M Substance	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
2-(2-Methoxyethoxy) ethanol (see Diethylene glycol monomethyl ether)					
2-Methoxyethyl acetate <sub>(skin)</sub>	[110-49-6]	5	24		
4-Methoxyphenol	[150-76-5]		5		
2-Methoxy-1-propanol	[1589-47-5]				
1-Methox-2-propyl acetate	[108-65-6]				
2-Methoxy1-propyl acetate	[70657-70-4]				
Methyl acetate	[79-20-9]	200	606	250	757
Methyl acetylene	[74-99-7]	1,000	1,640		
Methyl acetylene-propadiene mixture (MAPP)	[59355-75-8]	1,000	1,640	1,250	2,050
Methyl acrylate <sub>(skin)</sub>	[96-33-3]	10	35		
Methylacrylonitrile <sub>(skin)</sub>	[126-98-7]	1	2.7		
Methylal	[109-87-5]	1,000	3,110		
Methyl alcohol <sub>(skin), (bio)</sub>	[67-56-1]	200	262	250	328
Methylamine	[74-89-5]	10	13		
Methyl amyl alcohol (see Methyl isobutyl carbinol)					
Methyl n-amyl ketone	[110-43-0]	50	233		
N-Methyl aniline <sub>(skin)</sub>	[100-61-8]	0.5	2.2		
Methyl bromide <sub>(skin)</sub>	[74-83-9]	5	19		
Methyl tert-butyl ether <sub>6.7B</sub>	[1634-04-4]				
Methyl n-butyl ketone <sub>(skin)</sub>	[591-78-6]	5	20		
Methyl chloride <sub>(skin)</sub>	[74-87-3]	50	103	100	207
Methyl chloroacetate	[96-34-4]				
Methyl chloroform	[71-55-6]	125	680		

M Substance	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
Methyl 2-cyanoacrylate	[137-05-3]	2	9.1	4	18
Methylcyclohexane	[108-87-2]	400	1,610		
Methylcyclohexanol	[25639-42-3]	50	234		
o-Methylcyclohexanone (skin)	[583-60-8]	50	229	75	344
2-Methylcyclopentadienyl manganese tricarbonyl, as Mn (skin)	[12108-13-3]		0.2		
Methylene bisphenyl isocyanate (see Isocyanates)					
Methylene chloride 6.7B	[75-09-2]	50	174		
4,4-Methylene bis(2-chloroaniline) (skin) 6.7A	[101-14-4]		0.005		
Methylene bis(4-cyclohexylisocyanate) (see Isocyanates)					
4,4-Methylene dianiline (skin) 6.7A	[101-77-9]	0.01	0.08		
Methyl ethyl ketone (bio)	[78-93-3]	150	445	300	890
Methyl ethyl ketone peroxide	[1338-23-4]	Ceiling 0.2ppm (1.5mg/m <sup>3</sup> )			
Methyl formate	[107-31-3]	100	246	150	368
5-Methyl-3-heptanone (see Ethyl amyl ketone)					
Methyl iodide (skin)	[74-88-4]	2	12		
Methyl isoamyl ketone	[110-12-3]	50	234		
Methyl isobutyl carbinol (skin)	[108-11-2]	25	104	40	167
Methyl isobutyl ketone	[108-10-1]	50	205	75	307
Methyl isopropyl ketone	[563-80-4]	200	705		
Methyl mercaptan	[74-93-1]	0.5	0.98		
Methyl methacrylate (skin), (sen)	[80-62-6]	50	208	100	416
Methyl parathion (skin)	[298-00-0]		0.2		

<b>M</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Methyl propyl ketone	[107-87-9]	200	705	250	881
	1-Methyl-2-pyrrolidone <sub>(skin)</sub>	[872-50-4]	25	103	75	309
	Methyl silicate	[681-84-5]	1	6		
	α-Methyl styrene	[98-83-9]	50	242	100	483
	Methyl-tert butyl ether	[1634-04-4]	25	92	75	275
	Methyl vinyl ketone	[78-94-4]				
	Metribuzin	[21087-64-9]		5		
	<b>Mica <sup>(2011)</sup></b>	<b>[12001-26-2]</b>		<b>3mg/m<sup>3</sup> Respirable dust</b>		
	Mineral wool fibre (see Synthetic mineral fibres)					
	MOCA (see 4,4-Methylene bis(2-chloroaniline))					
	Molybdenum, as Mo	[7439-98-7]				
	Soluble compounds			5		
	Insoluble compounds			10		
	Monochloroacetic acid <sub>(skin)</sub>	[79-11-8]	0.3	1.2		
	Monochlorobenzene (see Chlorobenzene)					
	Morpholine <sub>(skin)</sub>	[110-91-8]	20	71		

N	Substance	CAS #	TWA		STEL	
			ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
	Naled (skin)	[300-76-5]		3		
	Naphthalene	[91-20-3]	10	52	15	79
	β-Naphthylamine 6.7A	[91-59-8]				
	Neon	[7440-01-9]	Simple asphyxiant			
	Nickel metal (sen)	[7440-02-0]		1		
	Soluble compounds, as Ni (sen)			0.1		
	Nickel sulphide roasting, fume & dust, as Ni (sen) 6.7A			1		
	Nicotine (skin)	[54-11-5]		0.5		
	Nitric acid	[7697-37-2]	2	5.2	4	10
	Nitric oxide	[10102-43-9]	25	31		
	p-Nitroaniline (skin)	[100-01-6]		3		
	Nitrobenzene (skin) 6.7B	[98-95-3]	1	5		
	p-Nitrochlorobenzene (skin) 6.7B	[100-00-5]	0.1	0.64		
	4-Nitrodiphenyl (skin) 6.7A	[92-93-3]				
	Nitrochloromethane (see Chloropicrin)					
	Nitroethane	[79-24-3]	100	307		
	Nitrogen	[7727-37-9]	Simple asphyxiant			
	Nitrogen dioxide	[10102-44-0]	3	5.6	5	9.4
	Nitroglycerin (NG) (skin)	[55-63-0]	0.05	0.46		
	Nitromethane 6.7B	[75-52-5]	20	50		
	1-Nitropropane	[108-03-2]	25	91		
	2-Nitropropane 6.7A	[79-46-9]	5	19		
	N-Nitrosodimethylamine (skin) 6.7B	[62-75-9]				

<b>N</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Nitrotoluene <small>(skin)</small>	[88-72-2; 99-08-1; 99-99-0]	2	11		
	Nitrous oxide	[10024-97-2]				
	Nonane	[111-84-2]	200	1,050		
	Nuisance particulates (see Particulates not otherwise classified)					

<b>O</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
		<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
Octane	[111-65-9]	300	1,400	375	1,750
Oil mist, mineral	[8012-95-1]		5 <sup>(e)</sup>		10
Osmium tetroxide, as Os	[20816-12-0]	0.0002	0.0016		
Oxalic acid	[144-62-7]		1		2
Ozone	[10028-15-6]	Ceiling 0.1ppm (0.20mg/m <sup>3</sup> )			

<b>P</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Paraffin wax fume	[8002-74-2]		2		
	Paraquat	[4685-14-7]		0.1 Respirable		
	Particulate polycyclic aromatic hydrocarbons (see Coal tar pitch volatiles)					
	Particulates not otherwise classified			10mg/m <sup>3</sup> Inhalable dust  3mg/m <sup>3</sup> Respirable dust		
	PCBs (see Polychlorinated Biphenyls) <sup>(f)</sup>					
	Pentachloronaphthalene	[1321-64-8]		0.5		
	<b>Pentachloronitrobenzene<sup>(2011)</sup></b>	<b>[82-68-8]</b>		<b>0.5</b>		
	Pentachlorophenol <sub>(skin)</sub> 6.7B	[87-86-5]		0.5		
	Pentaerythritol	[115-77-5]		10		
	Pentane	[109-66-0]	600	1,770	750	2,120
	2-Pentanone (see Methyl propyl ketone)					
	Perchloroethylene 6.7B	[127-18-4]	50	335	150	1005
	Perchloromethyl mercaptan	[594-42-3]	0.1	0.76		
	Perlite	[93763-70-3]		10 <sup>(a)</sup>		
	Petrol (Gasoline)	[8006-61-9]	300	890	500	1,480
	Phenacyl chloride (see α-Chloroacetophenone)					
	Phenol <sub>(skin)</sub>	[108-95-2]	5			
	Phenothiazine	[92-84-2]		5		
	2-Phenoxyethanol	[122-99-6]				
	N-Phenyl-2-Napthalenamine 6.7B	[135-88-6]				

<b>P</b>	Substance	CAS #	TWA		STEL	
			ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
	<b>m- Phenylenediamine</b> <sup>(2011)</sup>	[108-45-2]		<b>0.1</b>		
	<b>o- Phenylenediamine</b> <sup>6.7B</sup>	[95-54-5]		<b>0.1</b>		
	<b>p- Phenylenediamine</b> <sup>(skin)</sup>	[106-50-3]		<b>0.1</b>		
	Phenyl ether vapour	[101-84-8]	1	7	2	14
	Phenylethylene (see Styrene, monomer)					
	Phenyl glycidyl ether (PGE) <sup>(sen)</sup> <sup>(skin) 6.7B</sup>	[122-60-1]	1	6.1		
	Phenylhydrazine <sup>(skin)</sup> <sup>(sen) 6.7B</sup>	[100-63-0]	0.1	0.44		
	Phenyl mercaptan	[108-98-5]	0.5	2.3		
	Phenylphosphine	[638-21-1]	Ceiling 0.05ppm (0.23mg/m <sup>3</sup> )			
	Phorate <sup>(skin)</sup>	[298-02-2]		0.05		0.2
	Phosgene	[75-44-5]	0.02	0.08	0.06	0.25
	Phosphine	[7803-51-2]	0.3	0.42	1	1.4
	Phosphoric acid	[7664-38-2]		1		
	Phosphorous (yellow)	[7723-14-0]		0.1		
	Phosphorous oxychloride	[10025-87-3]	0.1	0.63		
	Phosphorous pentachloride	[10026-13-8]	0.1	0.85		
	Phosphorous pentasulphide	[1314-80-3]		1		
	Phosphorous pentoxide	[1314-56-3]				
	Phosphorous trichloride	[7719-12-2]	0.2	1.1	0.5	2.8
	Phthalic anhydride <sup>(sen)</sup>	[85-44-9]	1	16.1		
	m-Phthalodinitrile	[626-17-5]		5		
	Picloram	[1918-02-1]		10		
	Picric acid	[88-89-1]		0.1		
	Pindone	[83-26-1]		0.1		

<b>P</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Piperazine dihydrochloride	[142-64-3]		5		
	Piperidine <sub>(skin)</sub>	[110-89-4]	1	3.5		
	2-Pivalyl-1,3-indandione (see Pindone)					
	Plaster of Paris (see Calcium sulphate)					
	Platinum metal Soluble salts, as Pt <sub>(sen)</sub>	[7440-06-4]		1 0.002		
	Polychlorinated Biphenyls <sup>(f)</sup>	[1336-36-3]		0.1		
	Polytetrafluoroethylene (decomposition products)	[9002-84-0]				
	Polyvinyl chloride	[9002-86-2]				
	Portland cement	[65997-15-1]		10 <sup>(a)</sup>		
	Potassium hydroxide	[1310-58-3]		Ceiling 2mg/m <sup>3</sup>		
	PPAH (see Coal tar pitch volatiles)					
	Precipitated silica (see Silica-Amorphous)					
	Propane	[74-98-6]	Simple asphyxiant – may present an explosion hazard			
	Propane-1,2-diol Vapour & particulates Particulates only	[57-55-6]	150	474 10		
	Propane sultone <sub>6.7B</sub>	[1120-71-4]				
	Propargyl alcohol <sub>(skin)</sub>	[107-19-7]	1	2.3		
	β-Propiolactone <sub>6.7B</sub>	[57-57-8]	0.5	1.5		
	Propionic acid	[79-09-4]	10	30		
	Propoxur <sub>6.7B</sub>	[114-26-1]		0.5		
	2-Propoxyethanol	[2807-30-9]				
	Propanolol	[525-66-6]		2		6

<b>P</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	n-Propyl acetate	[109-60-4]	200	835	250	1,040
	n-Propyl alcohol (skin)	[71-23-8]	200	492	250	614
	Propylene	[115-07-1]	Simple asphyxiant – may present an explosion hazard			
	Propylene dichloride	[78-87-5]	75	347	110	508
	Propylene glycol dinitrate (skin)	[6423-43-4]	0.05	0.34		
	Propylene glycol monomethyl ether	[107-98-2]	100	369	150	553
	Propylene imine (skin) 6.7B	[75-55-8]	2	4.7		
	Propylene oxide 6.7B	[75-56-9]	5	12		
	n-Propyl nitrate	[627-13-4]	25	107	40	172
	Propyne (see Methyl acetylene)					
	Pyrethrum (sen)	[8003-34-7]		5		
	Pyridine	[110-86-1]	5	16		
	Pyrocatechol (see Catechol)					

<b>Q</b>		<b>TWA</b>		<b>STEL</b>	
		<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
<b>Substance</b>	<b>CAS #</b>				
Quartz (see Silica-Crystalline)					
Quinone	[106-51-4]	0.1	0.44		

<b>R</b>		TWA		STEL		
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>	
	<b>Substance</b>	<b>CAS #</b>				
	RDX (see Cyclonite)					
	<b>Resorcinol</b> <sup>(2011)</sup>	<b>[108-46-3]</b>	<b>10</b>	<b>45</b>	<b>20</b>	<b>90</b>
	Rhodium metal	[7440-16-6]		1		
	Insoluble compounds, as Rh			1		
	Soluble compounds, as Rh			0.01		
	Rosin core solder thermal decomposition products as resin acids (colophony) <sub>(sen)</sub>		Reduce to the lowest practicable level			
	Rotenone (commercial)	[83-79-4]		5		
	Rouge			10 <sup>2</sup>		
	Rubber process dust			6		
	Fume (see rubber fume and rubber process dust)			0.6		
	Rubber solvent (Naptha)		400	1,600		

<b>S</b>		<b>TWA</b>		<b>STEL</b>	
		<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	<b>Substance</b>	<b>CAS #</b>			
	Selenium and compounds, as Se	[7782-49-2]		0.1	
	Silane (see Silicon tetrahydride)				
	<b>Silica-Amorphous</b> Diatomaceous earth (not calcined) Precipitated silica Silica gel Silica fused	[61790-53-2]   [60676-86-0]		10 <sup>(a)</sup> 10 <sup>(a)</sup> 10 <sup>(a)</sup> 0.2 Respirable dust	
	<b>Silica-Crystalline</b> <sup>(2011)</sup> 6.7A <b>Cristobalite</b>  <b>Quartz</b>  <b>Tridymite</b>  <b>Tripoli</b>	[14464-46-1]  [14808-60-7]  [15468-32-3]  [1317-95-9]		0.1 Respirable dust 0.2 Respirable dust 0.1 Inhalable dust 0.2 Respirable dust of contained respirable quartz	
	Silica fume			2mg/m <sup>3</sup> Respirable dust	
	Silica fused (see Silica-Amorphous)				
	Silica gel (see Silica-Amorphous)				
	Silicon	[7440-21-3]		10 <sup>(a)</sup>	
	Silicon carbide	[409-21-2]		10 <sup>(a)</sup>	
	Silicon tetrahydride	[7803-62-5]	5	6.6	
	Silver metal Soluble compounds, as Ag	[7440-22-4]		0.1 0.01	
	Soapstone			3mg/m <sup>3</sup> Respirable dust  6mg/m <sup>3</sup> Inhalable dust	
	Sodium azide	[26628-22-8]	Ceiling 0.11ppm (0.29mg/m <sup>3</sup> )		

<b>S</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Sodium bisulphate	[7631-90-5]		5		
	Sodium fluoroacetate (1080) <small>(skin)</small> <small>(bio)</small>	[62-74-8]		0.05		
	Sodium hydroxide	[1310-73-2]		Ceiling 2mg/m <sup>3</sup>		
	Sodium dichloroisocyanurate	[2893-78-9]				
	Sodium disulphite	[7681-57-4]		5		
	Starch	[9005-25-8]		10 <sup>(a)</sup>		
	Stearates			10 <sup>(a)</sup>		
	Stibine	[7803-52-3]	0.1	0.51		
	Stoddard solvent (see White spirits)					
	Strontium chromate, as Cr <sub>6,7A</sub>	[7789-06-2]		0.001		
	Strychnine	[57-24-9]		0.15		
	Styrene, monomer <small>(skin)</small>	[100-42-5]	50	213	100	426
	Subtilisins (Proteolytic enzymes, as 100% pure crystalline enzyme) <small>(skin)</small>	[1395-21-7]; [9014-01-1]		Ceiling 0.00006mg/m <sup>3</sup>		
	Sucrose	[57-50-1]		10 <sup>(a)</sup>		
	Sulfotep <small>(skin)</small>	[3689-24-5]		0.2		
	Sulphur dioxide	[7446-09-5]	2	5.2	5	13
	Sulphur hexafluoride	[2551-62-4]	1,000	5,970		
	Sulphuric acid <sub>6,7A</sub>	[7664-93-9]		1		
	Sulphur monochloride	[10025-67-9]	Ceiling 1ppm (5.5mg/m <sup>3</sup> )			
	Sulphuryl fluoride	[2699-79-8]	5	21	10	42
	Synthetic mineral fibres			1 Respirable fibre per millilitre air and 5mg/m <sup>3</sup> Inhalable dust		

T Substance	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
2,4,5-T	[93-76-5]		10		
Talc (containing no asbestos fibres)	[14807-96-6]		2mg/m <sup>3</sup> Respirable dust		
Talc (containing asbestos fibres)		Use asbestos standards			
<b>Tantalum metal</b>	<b>[7440-25-7]</b>		<b>5</b>		
<b>Oxide dusts <sup>(2011)</sup></b>	<b>[1314-61-0]</b>		<b>5</b>		
TDI (see Isocyanates)					
TEDP (see Sulfotep)					
Tellurium and compounds, as Te	[13494-80-9]		0.1		
Temephos	[3383-96-8]		10		
Terephthalic acid	[100-21-0]		10		
Terphenyls	[26140-60-3]	Ceiling 0.5ppm (4.7mg/m <sup>3</sup> )			
1,1,1,2-Tetrachloro-2,2-difluoroethane	[76-11-9]	500	4,170		
1,1,2,2-Tetrachloro-1,2-difluoroethane	[76-12-0]	500	4,170		
1,1,2,2-Tetrachloroethane <sub>(skin)</sub> 6.7B	[79-34-5]	1	6.9		
Tetrachloroethylene (see Perchloroethylene)					
Tetrachloromethane (see Carbon tetrachloride)					
Tetraethyl lead, as Pb <sub>(skin), (bio)</sub>	[78-00-2]		0.1 <sup>(g)</sup>		
1,1,1,2-Tetrafluoroethane (HCF 134a)	[811-97-2]	1,000			
Tetrafluoroethylene 6.7B	[116-14-3]				
Tetrahydrofuran <sub>(skin)</sub>	[109-99-9]	100	295		

T Substance	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
Tetramethyl succinonitrile (skin)	[3333-52-6]	0.5	2.8		
Tetrasodium pyrophosphate	[7722-88-5]		5		
Tetryl (sen)	[479-45-8]		1.5		
Thallium soluble compounds, as Tl (skin)	[7440-28-0]		0.1		
4,4'-Thiobis(6-tert-butyl-m-cresol)	[96-69-5]		10		
Thioglycolic acid (skin)	[68-11-1]	1	3.8		
Thionyl chloride	[7719-09-7]	Ceiling 1ppm (4.9mg/m <sup>3</sup> )			
Thiram	[137-26-8]		1		
Tin metal	[7440-31-5]		2		
Oxide & inorganic compounds, except SnH <sub>4</sub> , as Sn			2		
Organic compounds, as Sn (skin)			0.1		0.2
Titanium dioxide	[13463-67-7]		10 <sup>(a)</sup>		
TNT (see 2,4,6-Trinitrotoluene)					
o-Tolidine (skin) 6.7B	[119-93-7]				
Toluene (skin)	[108-88-3]	50	188		
Toluene-2,4-diisocyanate (see Isocyanates)					
p-Toluenesulphonyl chloride	[98-59-9]				
o-Toluidine (skin) 6.7B	[95-53-4]	0.2	0.89		
m-Toluidine (skin)	[108-44-1]	2	8.8		
p-Toluidine (skin) 6.7B	[106-49-0]	2	8.8		
Toluol (see Toluene)					
Tributyl phosphate	[126-73-8]	0.2	2.2		

T Substance	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
Tri-n-butyltin compounds (as TBTO)	[56-35-9]				
Trichloroacetic acid <sup>6.7B</sup>	[76-03-9]	1	6.7		
1,2,4-Trichlorobenzene	[120-82-1]	Ceiling 5ppm (37mg/m <sup>3</sup> )			
1,1,1-Trichloroethane (see Methyl chloroform )					
1,1,2-Trichloroethane <sub>(skin)</sub>	[79-00-5]	10	55		
Trichloroethylene	[79-01-6]	50	269	200	1,070
Trichlorofluoromethane	[75-69-4]	Ceiling 1,000ppm (5,620mg/m <sup>3</sup> )			
Trichloroisocyanuric acid	[87-90-1]				
Trichloromethane (see Chloroform)					
Trichloronaphthalene <sub>(skin)</sub>	[1321-65-9]		5		
Trichloronitromethane see (Chloropicrin)					
1,2,3-Trichloropropane <sub>(skin)</sub> <sup>6.7B</sup>	[96-18-4]	10	60		
1,1,2-Trichloro-1,2,2-trifluoroethane	[76-13-1]	1,000	7,670	1,250	9,590
Tridymite (see Silica-Crystalline)					
<b>Triethanolamine<sup>(2011)</sup></b>	<b>[102-71-6]</b>		<b>5</b>		
Triethylamine <sub>(skin)</sub>	[121-44-8]	3	12	5	20
Trifluorobromomethane	[75-63-8]	1,000	6,090		
Triglycidyl isocyanurate (TGIC)	[2451-62-9]		0.08		
Trimellitic anhydride <sub>(sen)</sub>	[522-30-7]	0.005	0.039		
Trimethylamine	[75-50-3]	10	24	15	36
Trimethyl benzene	[25551-13-7]	25	123		

T Substance	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
Trimethyl phosphite	[121-45-9]	2	10		
2,4,6-Trinitrophenol (see Picric acid)					
2,4,6-Trinitrophenylmethylnitramine (see Tetryl)					
2,4,6-Trinitrotoluene (skin)	[118-96-7]		0.5		
Triorthocresyl phosphate (skin)	[78-30-8]		0.1		
Triphenyl amine	[603-34-9]		5		
Triphenyl phosphate	[115-86-6]		3		
Tripoli (see Silica-Crystalline)					
Tungsten, as W Insoluble compounds Soluble compounds	[7440-33-7]		5 1		10
Turpentine (wood C <sub>10</sub> H <sub>16</sub> ) (sen)	[8006-64-2]	100	556		

<b>U</b>		<b>TWA</b>		<b>STEL</b>	
		<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
Uranium (natural) soluble & insoluble compounds, as U <sub>6.7A</sub>	[7440-61-1]		0.2		

V Substance	CAS #	TWA		STEL	
		ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
n-Valeraldehyde	[110-62-3]	50	176		
Vanadium, as V <sub>2</sub> O <sub>5</sub> Respirable dust & fume	[1314-62-1]		0.05		
Vegetable oil mists			10 <sup>(a)</sup>		
Vinyl acetate <sub>6.7B</sub>	[108-05-4]	10	35	20	70
Vinyl benzene (see Styrene)					
Vinyl bromide <sub>6.7A</sub>	[593-60-2]	5	22		
Vinyl chloride <sub>6.7A</sub>	[75-01-4]	5	13		
Vinyl cyanide (see Acrylonitrile)					
4-Vinyl cyclohexane <sub>6.7B</sub>	[100-40-3]				
Vinyl cyclohexene dioxide <sub>(skin) 6.7B</sub>	[106-87-6]	10	57		
Vinylidene chloride	[75-35-4]	5	20	20	79
Vinyl toluene	[25013-15-4]	50	242	100	483

<b>W</b>	<b>Substance</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
			<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
	Warfarin	[81-81-2]		0.1		
	Welding fumes (not otherwise classified)			5 <sup>(d)</sup>		
	White spirits (Stoddard solvent)	[8052-41-3]	100	525		
	Wood dust, hard <sub>(sen)</sub> confirmed/suspected carcinogen depending on hard wood type			1		
	<b>Wood dust, soft<sup>(D2010) (2011)</sup></b>			<b>2 mg/m<sup>3</sup> (8 hour shift) 2 mg/m<sup>3</sup> (12 hour shift)<sup>v</sup></b>		

**Wood Species: Hardwood and Softwood Classification List**

<b>Hardwood</b>	<b>Softwood</b>
Taraire	Kauri
Tawa	Silver Pine
Akeake	Pink Pine
Kohekohe	Yellow-Silver Pine
Hinau	Rimu
Fuchsia	Kaikawaka (New Zealand Cedar)
Broadleaf	Tanekaha
Black Maire	Miro
Rewarewa	Matai
Pukatea	Totara
Manuka	Kahikatea
Kanuka	Macrocarpa
Mangeao	
Pohutukawa	
Southern Rata	
Northern Rata	
Southern Beech	
Kowhai	
Puriri	
Kamaha	

<sup>v</sup> Implementation of the eight and 12-hour shift WES will be staged over a two-year period commencing from 13<sup>th</sup> December 2010.

<b>X</b>	<b>CAS #</b>	<b>TWA</b>		<b>STEL</b>	
		<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
Xylene (o-, m-, p-isomers)	[1330-20-7]; [95-47-6]; [108-38-3]; [106-42-3]	50	217		
m-Xylene a,a'-diamine <small>(skin)</small>	[1477-55-0]		Ceiling 0.1mg/m <sup>3</sup>		
Xylidine mixed isomers <small>(skin) 6.7B</small>	[1300-73-8]	0.5	2.5		

<b>Y</b>		<b>TWA</b>		<b>STEL</b>	
		<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
Yttrium metal & compounds, as Y	[7440-65-5]		1		

<b>Z</b>		<b>TWA</b>		<b>STEL</b>	
		<b>ppm</b>	<b>mg/m<sup>3</sup></b>	<b>ppm</b>	<b>mg/m<sup>3</sup></b>
Zinc chloride fume	[7646-85-7]		1		2
Zinc chromates, as Cr <sub>6,7A</sub>	[13530-65-9]; [11103-86-9]; [37300-23-5]		0.01		
Zinc oxide fume Dust	[1314-13-2]		5 10 <sup>(a)</sup>		10
<b>Zirconium &amp; compounds, as Zr (2011)</b>	<b>[7440-67-7]</b>		<b>5</b>		<b>10</b>



# Biological Exposure Indices

# 1. BIOLOGICAL EXPOSURE INDICES

## 1.1 Introduction

Biological monitoring – the measurement of a substance or its metabolites in body fluids such as urine or blood – provides a complementary approach to air monitoring for estimating exposure to workplace contaminants.

A **Biological Exposure Index (BEI)** is considered by the ACGIH as a value often corresponding to the WES. If a worker's inhalation exposure is equal to the WES, and he/she is engaged in moderate work, then the BEI represents the expected level of the biological determinant.

This applies where (as in most cases), the BEI has been derived from the observed relationship between the measured air levels and measured biological (e.g. blood or urine) levels as this knowledge enables extrapolation from a WES to a BEI level. However, in some cases (such as with lead), the relationship between the biological level and the potential health effects has been approached more directly (e.g. by identifying adverse effects as a function of blood lead levels).

## 1.2 Exposure Periods

Depending on the pharmacokinetics of the substance, the results from the biological determination may reflect very recent exposure, the average exposure over the last day(s), or long-term cumulative exposure. The BEIs listed in this publication assume that exposure has been reasonably steady and that an eight-hour day, five-day week has been worked. Extrapolation to other exposures can be made, but only with a clear understanding of the relationship between absorption, metabolism, and elimination.

## 1.3 Effectiveness

Biological monitoring has been widely used to monitor the uptake of cumulative toxins (e.g. lead, mercury, organophosphate insecticides). It also may be employed effectively where there is a significant potential for increased uptake as a result of skin absorption, increased respiratory rate, or exposure outside the workplace (even if there is no change in workplace air levels).

The effectiveness of hazard control measures taken to limit uptake may also in some cases be assessed with follow-up biological monitoring tests. As with air monitoring, the design of the monitoring protocol and interpretation of results should only be done by a person with the appropriate qualifications and experience.

The fact that a BEI has been listed for a particular substance does not imply that biological monitoring is necessary. An appraisal of the exposure should be made before considering monitoring requirements.

## 1.4 Biological Assays

Several conditions must be satisfied for a biological assay to be a reliable indicator of exposure to a substance. The fate of the substance in the human body must have been adequately researched, and a time/concentration relationship must exist. It is not essential for the concentration of the determinant to be zero in cases where there is no occupational exposure, as long as the increase is measurably observable above the background level.

The biological assay must be as sensitive and specific as possible. While the concentration of the major metabolite may be high, and therefore easily detected, if it is a metabolite that is common to several substances, the determination of the unaltered substance, or minor metabolite, may be preferable.

The biological assay is often performed at a remote laboratory, therefore the determinant must be stable in the biological fluid.

## 1.5 Legal Requirements

Section 10 of the HSE Act requires employers to take “all practicable steps” to minimise hazards that cannot be eliminated or isolated. In workplaces where health monitoring can be used to identify workers’ health effects at an early stage for effective treatment, section 10(2)(d)-(e) requires employers to take all practicable steps to obtain the employees’ consent to the monitoring of their health in relation to the hazard, and only conduct monitoring with that consent.

This means an employer needs to be proactive in seeking approval, and take responsibility for informing and encouraging employees about health monitoring where appropriate. However, consent must be granted voluntarily and without any form of coercion or duress on the part of the employer seeking consent.

Section 11 of the HSE Act requires the employer to give the results of monitoring to affected employees. Where the monitoring results relate to biological monitoring, the employer shall ensure that the results of each worker’s monitoring is kept private and only made known to the worker, the employer, and health professionals if necessary.

## 1.6 Issues with Biological Monitoring

Generally a BEI as assessed by only one specific assay method is given for each substance, even though there may be several ways of estimating exposure. Preference has been given to urinary assays over more invasive blood tests, but factors such as the stability of the sample and the possibility of sample interference should be considered. Cultural sensitivity of the worker towards submitting a particular type of sample may also influence the selection of the biological monitoring procedure. Alternative methods may be available, especially for monitoring exposure to solvents<sup>(2,11)</sup>.

For the routine surveillance of exposure to some substances, biological monitoring may be preferred over air sampling. For example, if the substance has a long half-time in the body, the biological monitoring assay will give a result that reflects an integrated exposure, with little variation no matter when the sample is taken. In other cases, the corresponding air sampling procedure may, because of the typical work practices or sampling difficulties encountered, give less reliable results than biological monitoring.

Quantitative interpretation of biological monitoring results is often difficult. The overall value of the information may be improved if measurements are obtained from several workers with similar exposure, and/or serial determinations on an individual worker are conducted.

### 1.7 Information prior to Monitoring

Before undertaking a biological monitoring exercise, it is essential that background information be obtained, including data on the pharmacokinetics of the substances, interferences, and "background" levels of the determinant arising from non-workplace exposures. The following two references are recommended as a source of the relevant background material:

- a) *ACGIH Documentation of the Threshold Limit Values and Biological Exposure Indices* <sup>(2)</sup>
- b) *Industrial Chemical Exposure, Guidelines for Biological Monitoring* <sup>(11)</sup>.

### 1.8 Sample Collection

It is important to observe the timing of the sample collection for each determination. The level of a substance, or its metabolic products, will vary with the time elapsed since the last exposure, and the biological index for some chemicals is only applicable if the recommended timing of sample collection is closely adhered to.

Assuming that there has been continual exposure over the working day, the following potential sample periods (causing minimal disturbance of working routines) have received most attention. The most appropriate sample period for any given substance depends on how quickly it (or its measured metabolite) is eliminated from the body:

**Prior to (next) Shift:** Following a period of 16 hours with no exposure. (Appropriate for substances "promptly" but not rapidly eliminated).

**End of Shift:** The last two hours immediately following the end of the working day. (Appropriate for substances "rapidly" eliminated, whose measured levels could have fallen substantially if sampling was delayed until just prior to the next shift).

**End of Work Week:** After at least four days with exposure. (Appropriate for substances eliminated more slowly and thus incompletely over 24 hours, causing some accumulation, with the highest levels observed on the last day).

However, if the exposure has been confined to a portion of the working day, it may be necessary to adjust the timing, but it must be recognised that the estimation of exposure may be compromised.

Other factors may also compromise test results. Contamination of the sample could take place during collection as a result of inadequate cleaning of the skin prior to taking a blood sample, or on other inadvertent contamination of a specimen. Loss of sample integrity on storage and transport may occur through the use of an inappropriate container or storage conditions. Further details of the procedure to be followed for sample collection should be obtained from the laboratory carrying out the analysis.

## **1.9 Interpretation of Results**

Biological monitoring data must be interpreted with some caution. Especially useful is to compare any individual's result with their previous results (if any).

There are several reasons why the levels of the determinant may vary between individuals, even under seemingly identical exposure situations. Workers may differ in size, physical fitness and work practices, resulting in differing uptakes, such as through variations in respiration rate/volume and skin contact (and absorption). Further, there may be inter-individual differences in metabolism and elimination rates of the absorbed substance or contaminant.

Further advice on the application of biological monitoring can be obtained from the Department of Labour.

## 2. LEAD BIOLOGICAL EXPOSURE INDICES

This section should be read in conjunction with the Department of Labour publication [Guidelines for the Medical Surveillance of Lead Workers](#). The overall objective of the surveillance outlined in the guidelines is to maintain the blood lead levels of all workers below  $1.5\mu\text{mol/litre}$  whole blood. Medical surveillance, including blood lead monitoring, is extended to all those working with lead in a process that may result in blood lead levels above  $1.5\mu\text{mol/litre}$  whole blood.

### 2.1 Female Employees

While it is preferable for all employees' blood lead levels to stay at or below  $1.5\mu\text{mol/litre}$  whole blood, this value must be more stringent for pregnant women or women planning to become pregnant, because they should be exposed to as little lead as possible. Ideally, these women should have no exposure to lead at all, because the developing foetus is extremely susceptible to this substance. Additionally, accumulated lead can be released from the mothers' bones during times of calcium stress such as pregnancy and lactation.

### 2.2 Recommended Blood Lead Levels

(This subsection does not include employees who are pregnant, breastfeeding or women of child-bearing age).

An employee will normally be suspended by a Departmental Medical Practitioner where a single blood lead result is  $2.4\mu\text{mol/litre}$  whole blood or greater <sup>(2010)</sup>.

An employee can return to work if their blood levels achieve  $1.93\mu\text{mol/litre}$  whole blood or below <sup>(2010)</sup>.



# Table of Biological Exposure Indices

## TABLE OF BIOLOGICAL EXPOSURE INDICES

Exposure	Determinant	Sampling Time	BEI
Acetone	Acetone in urine	End of shift	50mg/litre
Arsenic	Sum of inorganic arsenic metabolites	End of shift at end of work week	100µg/litre
Cadmium	Cadmium in blood Cadmium in urine	Not critical Not critical	0.044µmol/litre (5µg/litre) 5µmol/mol creatinine (5µg/g creatinine)
Carbon monoxide	Carboxyhaemoglobin in blood	End of shift	3.5% of haemoglobin
Chromium (VI) water-soluble fume	Chromium in urine	End of shift at end of work week	0.6µmol/litre (30µg/litre)
Cobalt	Cobalt in urine	End of shift at end of work week	15µg/litre
2-Ethoxyethanol and 2-Ethoxyethyl acetate	2-ethoxyacetic acid in urine	End of shift at end of work week	100mg/g creatinine
Fluorides	Fluoride in urine	Prior to shift End of shift	160µmol/litre (3mg/litre) 530µmol/litre (10mg/litre)
n-Hexane	2,5-hexanedione in urine	End of shift	5mg/litre

Exposure	Determinant	Sampling Time	BEI
Lead (inorganic) (2010)	Lead in blood	Not critical	See section on lead biological exposure indices
	Lead in urine	Not critical	1.5 µmol/litre (150µg/litre)
Mercury	Mercury in urine	Not critical	0.25µmol/litre (50µg/litre)
Methyl alcohol	Methyl alcohol in urine	End of shift	15mg/litre
Methyl ethyl ketone (MEK)	MEK in urine	End of shift	2mg/litre
Methyl isobutyl ketone (MIBK)	MIBK in urine	End of shift	2mg/litre
Organophosphates	Cholinesterase activity in blood		<p><b>Recommended Action</b></p> <p>If less than 60% of Baseline: suspend from working with pesticides which inhibit cholinesterase activity</p> <p>If less than 80% of Baseline: repeat test to confirm result</p> <p>If greater than 75% of Baseline: permit a previously suspended worker to recommence normal duties</p>
Pentachlorophenol (PCP)	Total PCP (including conjugates) in urine	Prior to last shift of week	1mg/litre

<b>Exposure</b>	<b>Determinant</b>	<b>Sampling Time</b>	<b>BEI</b>
Phenol	Total phenol in urine	End of shift	250mg/g creatinine
Sodium fluoroacetate (1080)	Sodium fluoroacetate in urine	End of shift	15µg/litre
Styrene	Mandelic acid in urine	End of shift	1g/litre
Trichloroethylene	Trichloroacetic acid in urine	End of work week	100mg/litre
Xylene	Methylhippuric acid in urine	End of shift	1.5g/litre

## APPENDIX 1: DEFINITIONS

<b>6.7A Carcinogen</b>	Known or presumed human carcinogen
<b>6.7B Carcinogen</b>	Suspected human carcinogen.
<b>Acute Effects</b>	The effects of a substance experienced by a worker occur immediately or shortly after exposure.
<b>ACGIH</b>	American Conference of Governmental Industrial Hygienists.
<b>Agglomeration</b>	A mass or cluster.
<b>Allergenic</b>	A term applied to a substance that can cause an allergic response (development of an allergy to it, with allergic symptoms on re-exposure).
<b>Allergic Sensitisation</b>	The more often the worker is exposed to an allergen, the more severe the worker's reaction to the allergen becomes. Even at low exposures to the allergen, a sensitive reaction will occur.
<b>Alveoli</b>	The tiny air spaces or "sacs" at the end of the smallest passageways of the lungs. They are the sites of oxygen uptake.
<b>Animal Studies</b>	Also known as "Animal Testing": the practice of using animals in experiments, including for biomedical research or toxicology testing.
<b>Atmospheric Contaminants</b>	Potentially toxic dusts, fibres, fumes, mists, vapours or gases contaminating the air.
<b>Background Levels</b>	Levels of a substance in a worker's biological sample that can occur naturally (without any workplace exposure). They can occur due to the substance's normal presence in the environment or diet, or produced in the body itself.
<b>(bio)</b>	Exposure can also be estimated by biological monitoring.

<b>Biological Assay</b>	Also known as Bioassay, it is a particular type of test or experiment designed to determine the presence and/or concentration of a substance.
<b>Biological Exposure Index (BEI)</b>	Guidance values for assessing biological monitoring results. It indicates a concentration below which nearly all workers should not experience adverse health effects from exposure to a particular substance.
<b>Carboxyhaemoglobin Level</b>	A good indicator of the level of carbon monoxide present in the bloodstream. It is formed when haemoglobin binds preferentially to carbon monoxide instead of oxygen, which can severely reduce the delivery of oxygen to various parts of the body.
<b>Carcinogenic</b>	The description given to those hazardous/toxic substances that can cause cancer or contribute to its development.
<b>CAS #</b>	Short for Chemical Abstract Services Registry Number. This Registry assigns a unique identifying series of numbers to each individual chemical.
<b>Causal Relationship</b>	The relationship between an event and another event, where the second event is a consequence of the first, e.g. exposure to a confirmed cancer-causing agent can (or may) lead to cancer in the exposed person.
<b>Ceiling (WES-Ceiling)</b>	A concentration that should not be exceeded for any time during any part of the working day.
<b>Default Excursion Limit</b>	A limit for a substance which is set at three times the WES value for any 15-minute period of exposure. This can be used if no Ceiling or STEL have been established.
<b>Diffusion</b>	One way that airborne particulates within the airway channels can be deposited on the walls of the airways. See section on Aerosols for a more detailed definition.
<b>Dusts</b>	Discrete solid particles suspended in air. See section on Aerosols for a more detailed definition.
<b>Elimination Rate</b>	The calculated (or estimated) rate at which a substance is eliminated from the body.

<b>Epidemiological Studies</b>	Studies (of various types) on human populations, which are designed to help identify specific causes of adverse health effects, and the relative contribution of different causes.
<b>Equivalent Aerodynamic Diameter (AED)</b>	The diameter of a sphere of "unit density" (1 gram percm <sup>3</sup> ) that exhibits the same aerodynamic behaviour as that of the particle (of any shape or density) being measured.
<b>Fraction of Inhalable Mass</b>	Fractions of the inhalable mass are the particles that can penetrate beyond the upper respiratory tract (airways within the head and neck) and enter the thoracic airways (airways within the chest).
<b>Fibrogenic</b>	A substance that is known to generate "fibrotic" reactions in body organs or tissue. This process is also known as fibrosis, which is the development of excessive fibre-like or fibrous tissue, similar to what occurs with scarring.
<b>Fumes</b>	Airborne particulates with diameters generally less than 1 µm. See section on aerosols for a more detailed definition.
<b>Gas</b>	A state of matter characterised by low density and viscosity (compared to liquids and solids), and can usually expand and contract with changes in pressure and temperature. Gases can be in the form of individual atoms of an element (e.g. argon) but more usually comprise molecules, containing more than one atom of one or more elements (e.g. carbon dioxide).
<b>General Excursion Limit (GEL)</b>	Often there is insufficient toxicological data available for the establishments of a Short Term Exposure Limit. Peak Exposure should, however, still be controlled even in situations where the Time-Weighted Average level is not exceeded. In such cases, a 15-minute exposure limit of 3 times the TWA is recommended. Where a STEL has been assigned, the STEL value takes precedence over the General Excursion Limit, regardless of whether or not it is a stricter standard.
<b>Hazardous or Toxic Substance</b>	A substance (in gas, liquid or solid form) that has one, or more, of the following properties: <ul style="list-style-type: none"> <li>• Explosive</li> <li>• Flammable</li> <li>• Oxidising</li> <li>• Toxic (harmful to humans)</li> <li>• Corrosive</li> </ul>

- Ecotoxic (harmful to animals, soil, water or air).

<b>Histological Type</b>	<p>Histology is the study of microscopic anatomy of cells and tissues of plants and animals. There are five main types of histological tissue:</p> <ul style="list-style-type: none"> <li>• Muscle tissue (including cardiac muscle)</li> <li>• Nerve tissue</li> <li>• Connective tissue</li> <li>• Endothelial tissue (glands, bowel, skin, liver, lung, kidney)</li> <li>• Epithelial tissue (skin).</li> </ul>
<b>HSE Act</b>	The Health and Safety in Employment Act 1992.
<b>HSNO Act</b>	The Hazardous Substances and New Organisms Act 1996.
<b>Hygroscopic Particles</b>	Particles than can absorb water from their environment.
<b>Infectious</b>	The property of a living (biological) organism that is capable of causing an infection. This can occur when the body is invaded by pathogenic (disease-causing) microorganisms.
<b>Impaction, inertial</b>	A term for one mechanism or process that can cause airborne particulates to deposit on the airway walls. See section on Aerosols for a more detailed definition.
<b>Inhalable Dust</b>	Portion of airborne dust that is taken in through the mouth and nose during breathing.
<b>Irritative</b>	A substance capable of causing tissue inflammation when it contacts the skin, eyes, nose or respiratory system (usually with associated subjective feelings of irritation and discomfort, as well as objective evidence of inflammation).
<b>Laminarly Flowing Air</b>	Laminar Flow, or Streamline Flow, occurs when air flows in parallel layers with no disruption between the layers (because there is no air flow).
<b>Latency Period</b>	The period between contact with a chemical substance or biological pathogen and the development of symptoms.
<b>Long Term Exposure</b>	Exposure over a prolonged period, usually defined as greater than three months.
<b>Metabolism</b>	A term used to describe the process by which a substance is changed or "broken down" in the body, into metabolites

(changed substances). These metabolites are usually easier for the body to eliminate than the original substance is, but sometimes can be more toxic. "Metabolism" is also used more generally to describe the numerous, wide-ranging set of chemical reactions required for the body to function normally.

**Mists**

Small droplets of liquid suspended in air. See section on Aerosols for a more detailed definition.

**mg/m<sup>3</sup>**

mg = milligrams, and m<sup>3</sup> = cubic metres. mg/m<sup>3</sup> is used for reporting the concentration of solids (like dusts or metal fumes) in the worker's atmosphere (as mass per volume of air).

It can also be used for reporting airborne concentrations of liquid particles (mists) or even gases, although gases can be reported differently.

**No-Effect Level**

The maximum dose of a substance that produced no detectable changes under defined conditions of exposure.

**Particulate**

Tiny subdivisions of solid or liquid matter suspended in a gas. Not only the size but also the shape and density of a particulate determined its aerodynamic behaviour and so-called Equivalent Aerodynamic Diameter (AED). The AED can be used to predict how likely it will be inhaled and the region of the airways it will most likely deposit on.

**Pharmacokinetics (or Toxicokinetics)**

Pharmacokinetics describes the "movement" of a drug (or other potentially toxic compound) through the body. It includes the processes of absorption into the body, distribution within the body, modification or "break down" in the body, and elimination from the body, including different routes of elimination and whether in unchanged or changed form.

**Pharynx**

A vertically elongated tube that lies behind the nose, mouth and larynx. The middle section, the oropharynx, is located behind the throat. It serves as the upper passageway for the digestive and respiratory tracts, transporting air, water and food as necessary.

**ppm**

Parts of vapour or gas per million parts of air by volume at 25°C and 760 torr (atmospheric pressure).

<b>R-Phrase</b>	Risk phrase – describes the nature of special risks attributed to dangerous substances and preparations. Sourced from the European Union Directive 67/548/EEC.
<b>Respirable Dust</b>	The fraction of total inhalable dust that is able to penetrate and deposit in the lower bronchioles and alveolar region.
<b>Respiratory System</b>	<p>The complex of organs and structures that performs breathing or respiration. Normally this results in adequate ventilation, where sufficient amounts of ambient air are transported into the terminal regions of the lung, where the exchange of oxygen for carbon dioxide produced by the body occurs. (The oxygen is circulated through the body and the carbon dioxide is exhaled).</p> <p>The main organs and structures involved in the respiratory system are:</p> <ul style="list-style-type: none"> <li>• Nose</li> <li>• Pharynx</li> <li>• Larynx</li> <li>• Trachea, bronchi and lungs</li> <li>• Pleura (membrane surrounding lungs)</li> <li>• Blood and nerve supply.</li> </ul>
<b>Rubber Fume</b>	Any fume that evolves during the blending, milling and curing of natural rubbers or synthetic elastomers.
<b>Rubber Process Dust</b>	Dust generated during the manufacture of goods using natural rubber or synthetic elastomers.
<b>Safety Data Sheet</b>	A document that describes the hazardous properties of a substance, i.e. its identity, chemical and physical properties, health hazard information, precautions for use and safe handling information.
<b>Sedimentation</b>	A term used to describe one mechanism of how airborne particulates (or certain equivalent aerodynamic diameter) deposit onto the walls of airways in the respiratory tract. See section on Aerosols for a more detailed definition.

<b>Short-Term Exposure Limit (WES-STEL)</b>	The 15-minute exposure standard. Applies to any 15-minute period in the working day and is designed to protect the worker against adverse effects of irritation, chronic or irreversible tissue change, or narcosis that may increase the likelihood of accidents. The WES-STEL is not an alternative to the WES-TWA; both the short-term and time-weighted average exposures apply.
<b>(sen)</b>	Sensitiser – an alternative name for Allergen. A substance that can “sensitise” the skin or respiratory system, inducing a state of hypersensitivity to it, so that on subsequent exposures, an allergic reaction can occur (which would not develop in non-sensitised individuals). It is uncommon to become sensitised to a compound after just a single reaction to it.
<b>Simple asphyxiant</b>	A term generally given to non-toxic gases not capable of causing more direct forms of asphyxia. In high concentrations, these gases can physically displace oxygen from the breathing zone, decreasing oxygen uptake, with the risk of the person becoming asphyxiated. This is a particular concern in confined or restricted spaces, with reduced circulation of air.
<b>(skin)</b>	Skin absorption – applicable to a substance that is capable of being significantly absorbed into the body through contact with the skin.
<b>Substance</b>	A substance identified in this publication has properties making it toxic to human health.
<b>Synergistic Effect</b>	This occurs when the combined effect of two chemicals is substantially greater than the sum of the effects of each chemical on their own, e.g. $2 + 4 = 20$ (not 6, which would be a simple additive effect). It is slightly different from Potentiation, where the presence of one substance (without an effect) can enhance the effect on the target organ of another substance, e.g. $0 + 3 = 10$ (not 3).
<b>Terminal Velocity</b>	Terminal velocity occurs when the downward force of an object is equalled by the upward force of the object’s drag, making the net force on the object zero. In this state, the velocity (speed) of the object remains constant.

<b>Time-Weighted Average (WES-TWA)</b>	Most WES in New Zealand have a eight-hour TWA, representing a work shift of 8 hours over one day. This means that the value assigned for a WES-TWA should not be exceeded over the period of 8 hours during a working shift.
<b>Vapour</b>	A vapour is the gaseous form of a substance which more normally (e.g. under conditions of standard temperature (25°C) and pressure (760 mm Hg)) exists predominantly as a liquid or solid. This distinguishes it from those compounds which normally exist as gases.
<b>Vapour Phase Skin Absorption</b>	The degree to which a vapour can be absorbed through the skin (often made in comparison) to the degree the same compound can when its liquid form is in contact with the skin).
<b>µm</b>	Micrometre, or "micron". Its size is 1 millionth of a metre.
<b>µg</b>	Microgram. It is a unit of mass equal to 1 thousandth of a milligram.
<b>µmol</b>	Micromole, a unit of measurement for the amount of substance, or chemical amount.
<b>Unciliated Airways</b>	In the upper respiratory tract, fine hair-like projections from cells (cilia) "sweep" in unison to remove or clear fluids and particles. In the unciliated airways, of the lower respiratory tract (the alveolar region) cilia do not exist.
<b>Worker's Breathing Zone</b>	A hemisphere of 300mm radius extending in front of the worker's face and measured from the midpoint of an imaginary line joining the ears.
<b>Workplace Exposure Standard (WES):</b>	Workplace exposure standards are a value that refers to the airborne concentration of substances, at which it is believed that nearly all workers can be repeatedly exposed to day after day without coming to harm. The values are normally calculated on work schedules of five shifts of eight hours duration over a 40 hour work week.

## APPENDIX 2: REFERENCES

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- <sup>2</sup> American Conference of Governmental Industrial Hygienists (ACGIH). *Documentation of the Threshold Limit Values and Biological Exposure Indices*. 7<sup>th</sup> Edition, ACGIH, Cincinnati, Ohio.
- <sup>3</sup> National Occupational Health and Safety Commission. *Documentation of the Exposure Standards*. [NOHSC:10003(1990)], Australian Government Publishing Service, Canberra (1990).
- <sup>4</sup> Health and Safety Executive (UK). *Summary Criteria for Occupational Exposure Limits*, EH64 1996 and supplements.
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- <sup>6</sup> International Standards Organisation ISO 7708:1995 Particle Size Fraction Definitions for Health-Related Sampling.
- <sup>7</sup> Standards Australia, AS 3460:2009. *Workplace Atmospheres: Method for Sampling and Gravimetric Determination of Inhalable Dust*. Standards Australia, Sydney, (2009).
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- <sup>10</sup> Health and Safety Executive (UK). *Rubber Fume in Air, Measured as Total Particulates and Cyclohexane Soluble Material*. MDHS 47.
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