SPECIAL GUIDE

Workplace exposure standards and biological exposure indices

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WORKSAFE
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Preface

The fourteenth edition of the Workplace Exposure Standards and Biological Exposure Indices has been developed by Worksafe New Zealand (WorkSafe). Input has also been sought from a wide range of interested parties.

This edition supersedes all previous editions and versions.

WorkSafe will continue to review and revise this document to take into account any significant new toxicological or occupational hygiene information.

Changes in this edition

PAGE	TOPIC	CHANGES	RATIONALE
TABLE 4			
30	Acetic anhydride	Introduction of WES-TWA of 0.1ppm Introduction of WES-STEL of 0.2ppm Removal of WES-Ceiling	To protect for severe irritation of the eyes, mucous membranes and skin, and upper respiratory tract irritation.
30	Acrolein	Change of WES-TWA to 0.02ppm Introduction of WES-STEL of 0.05ppm	To protect for severe irritation of the eyes, mucous membranes and respiratory tract, and the potential development of pulmonary oedema.
30	α-Alumina	Entry removed and replaced with new entry 'Aluminium metal dust and insoluble compounds (including pyro powders, aluminium oxide and metal fumes) (as Al)'	
30	Aluminium oxide (α-Alumina)	Entry removed and replaced with new entry 'Aluminium metal dust and insoluble compounds (including pyro powders, aluminium oxide and metal fumes) (as Al)'	
30	Aluminium, Metal dust (as Al)	Entry removed and replaced with new entry 'Aluminium metal dust and insoluble compounds (as Al)'	
30	Aluminium metal dust and insoluble compounds (including pyro powders, aluminium oxide and metal fumes) (as Al)	New entry to replace individual entries for α-Alumina, Aluminium oxide, and Aluminium Metal dust (as Al) Establishment of WES-TWA of 1.0mg/m^3(r)	To protect for pneumoconiosis, lower respiratory tract irritation and neurotoxicity.
30	Aluminium, Alkyls (not otherwise classified) (as Al)	Removal of entry	WES-TWA removed due to inadequacy as relevant health-based limits have not been set or have been revoked.

PAGE	TOPIC	CHANGES	RATIONALE
30	Aluminium, Pyro powders (as Al)	Entry removed and replaced with new entry 'Aluminium metal dust and insoluble compounds (including pyro powders, aluminium oxide and metal fumes) (as Al)'	
	Aluminium, Soluble salts (as Al)	Removal of entry	WES-TWA removed due to inadequacy as relevant health-based limits have not been set or have been revoked.
30	Aluminium, Welding fumes (as Al)	Entry removed and replaced with new entry 'Aluminium metal dust and insoluble compounds (including pyro powders, aluminium oxide and metal fumes) (as Al)'	
32	Asphalt (petroleum) fumes	Change of WES-TWA to 0.5mg/m^3 Introduction of 'skin' notation	To protect for mucous membrane and eye irritation and potential carcinogenic risks.
32	Atrazine	Change of WES-TWA to 1mg/m^3	To protect for luteinizing hormone (LH) related reproductive effects and possibly developmental effects in progeny of exposed workers.
32	Azinphos-methyl	Introduction of 'bio' notation	Exposure can also be estimated by biological monitoring.
33	Beryllium and compounds (as Be)	Introduction of 'rsen' notation	Respiratory sensitiser.
34	tert-Butyl acetate	Change of WES-TWA to 20ppm Change of WES-STEL to 40ppm	To protect for acute CNS effects, and eye and mucous membrane effects.
34	tert-Butyl alcohol	Change of WES-TWA to 20ppm Change of WES-STEL to 80ppm	To protect for the damage and potentially, narcosis.
35	Calcium hydroxide	Change of WES-TWA to 1mg/m^3 Introduction of WES-STEL of 4mg/m^3	To protect for irritative effects and the potential for decreased lung function.
35	Carbaryl	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
36	Carbofuran	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
37	Chloroform	Change of WES-TWA to 0.5ppm	To protect for liver and kidney damage.
38	Chlorpyrifos	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
38	Chromyl chloride	Removal of entire entry	Chromyl chloride should be assessed as a 'Chromium (VI) compound, as Cr' and given an 'ifv' notation – the Inhalable Fraction and Vapour (ifv) notation is used when a material exerts sufficient vapour pressure such that it may be present in both particle and vapour phases, with each contributing to a significant portion of exposure.

PAGE	TOPIC	CHANGES	RATIONALE
39	Cresol, all isomers	Change of WES-TWA to 1ppm Introduction of 'ifv' notation	To protect for skin and mucous membrane irritation. The Inhalable Fraction and Vapour (ifv) notation is used when a material exerts sufficient vapour pressure such that it may be present in both particle and vapour phases, with each contributing to a significant portion of exposure.
40	Cyclohexylamine	Change of WES-TWA to 2ppm Introduction of WES-Ceiling of 5ppm Removal of 'dsen' notation	To protect for eye and nose irritation and neurobehavioural effects.
40	2,4-D	Change substance entry to '2,4-D (including salts and esters)' Introduction of 'skin' notation	Skin absorption.
40	Diazinon	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
40	Dibutyl phenyl phosphate	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
41	2-N-Dibutylaminoethanol	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
41	1,1-Dichloroethylene (Vinylidene chloride)	Change of WES-TWA to 2ppm Change of WES-STEL to 5ppm	To protect for liver and kidney effects, and neurotoxicity.
42	Dichlorvos	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
42	Dicyclopentadiene	Change of WES-TWA to 0.5ppm Introduction of WES-STEL of 1ppm	To protect for eye and respiratory tract irritation, and possible CNS effects.
43	Diisopropylamine	Introduction of a 'skin' notation	Skin absorption.
43	Dimethyl acetamide	Change of WES-TWA to 5ppm Introduction of a 'skin' notation	To protect for liver damage, reproductive and CNS effects, and developmental toxicity.
43	N,N-Dimethylethylamine	Change of WES-TWA to 2ppm Removal of WES-STEL Introduction of WES-Ceiling of 5ppm	To protect for visual disturbances, and eye and mucous membrane irritation.
44	Di-sec-octyl phthalate (Di(2-ethylhexyl)phthalate)	Change of WES-TWA to 2mg/m^3 Change of WES-STEL to 4mg/m^3 Introduction of a 'skin' notation	To protect for developmental effects in progeny of exposed workers. Skin absorption.
45	Ethanedinitrile (EDN)	Introduction of a 'PES' notation Introduction of an 'oto' notation	Prescribed exposure standard. Ototoxin.

PAGE	TOPIC	CHANGES	RATIONALE
45	Ethanolamine (2-Aminoethanol)	Change of WES-TWA to 0.2ppm Change of WES-STEL to 0.2ppm	To protect for irritation to the eyes and for morphological changes and local irritation to the respiratory tract.
46	Ethyl acrylate	Introduction of WES-TWA of 2ppm Introduction of WES-STEL of 4ppm Removal of WES-Ceiling Introduction of a 'skin' notation	To protect for eye, nose and respiratory tract irritation, and skin sensitisation. Skin absorption.
46	Ethyl alcohol (Ethanol)	Change of WES-TWA to 200ppm Change of WES-STEL to 800ppm	To protect for carcinogenicity, CNS depression, and irritation of the eyes and respiratory tract.
46	Ethyl butyl ketone (3-Heptanone)	Change of WES-TWA to 10ppm Change of WES-STEL to 20ppm	To protect for eye and mucous membrane irritation.
47	Ethylene glycol dinitrate	Removal of WES-TWA Introduction of WES-STEL of 0.01ppm	To protect for rapid hypertensive effects and headaches. Ethylene glycol dinitrate and propylene glycol dinitrate have additive effects.
47	Fluorine	Change WES-TWA to 0.1ppm Removal of WES-STEL Introduction of WES-Ceiling of 0.5ppm	To protect for acute irritation and potential chronic fluorosis.
50	Hydrogen fluoride, as F	Introduction of 'bio' notation	Exposure can also be estimated by biological monitoring.
51	Isoamyl alcohol	Change of WES-TWA to 5ppm Change of WES-STEL to 10ppm	To protect for local irritative effects to the upper respiratory tract and eyes.
52	Malathion	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
53	Mercury, Alkyl compounds (as Hg)	Removal of 'bio' notation Introduction of 'oto' notation	BEI only intended for elemental mercury. Elemental, organic, and inorganic mercury can have a ototoxic effect.
53	Mercury, Inorganic compounds (as Hg)	Removal of 'bio' notation Introduction of 'oto' notation	BEI only intended for elemental mercury. Elemental, organic, and inorganic mercury can have an ototoxic effect.
53	Mesityl oxide	Change of WES-TWA to 2ppm Introduction of 'skin' notation	To protect for eye and mucous membrane irritation. Skin absorption.
53	Methomyl	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
54	Methyl chloride	Change of WES-TWA to 20ppm	To predict for neurotoxicity and CNS effects.

PAGE	TOPIC	CHANGES	RATIONALE
54	Methyl isoamyl ketone	Change of WES-TWA to 20ppm Introduction of WES-STEL of 50ppm	To protect for eye and mucous membrane irritation, and potential CNS effects after peak exposures.
55	1-Methyl-2-pyrrolidone	Change of WES-TWA to 10ppm Change of WES-STEL to 20ppm	To protect for upper respiratory tract irritation, developmental toxicity, and CNS effects.
56	Naled (Dimethyl-1,2-dibromo-2,2-dichloroethyl phosphate)	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
57	Nitric oxide	Change of WES-TWA to 2ppm	To protect for respiratory tract irritation and lung damage.
57	Nitroethane	Change of WES-TWA to 10ppm Change of WES-STEL to 40ppm Introduction of 'skin' notation	To protect for sensory irritation and methaemoglobinaemia (and sequelae). Skin absorption.
57	1-Nitropropane	Change of WES-TWA to 2ppm Change of WES-STEL to 16ppm Introduction of a 'skin' notation	To protect for inflammation of the olfactory and squamous epithelia, and eye and respiratory tract irritation. Skin absorption.
58	Pentane	Change WES-STEL to 2210mg/m^3	To correct typographical error.
59	Phorate	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
59	Phosphine	Current values of WES-TWA of 0.3ppm and WES-STEL of 1ppm will be maintained as interim values with a change to WES-TWA of 0.05ppm, and WES-STEL of 0.2ppm to take effect in 2024	To protect for respiratory tract irritation and pulmonary oedema.
60	Phosphorus oxychloride	Change of WES-TWA to 0.01ppm Introduction of WES-STEL of 0.02ppm	To protect for eye and respiratory tract irritation.
61	Propoxur	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
61	Propylene glycol dinitrate	Removal of WES-TWA Introduction of WES-STEL of 0.01ppm	To protect for rapid hypotensive effects and headaches. Ethylene glycol dinitrate and propylene glycol dinitrate have additive effects.
63	Selenium and selenium compounds, as Se	Change of WES-TWA to 0.02mg/m^3 Introduction of 'skin' notation	To protect for prolongation of the prothrombin time and increased risk of diabetes mellitus. Skin absorption.
64	Silica-Crystalline (all forms)	Change of WES-TWA to 0.025mg/m^3(r)	To protect for pulmonary fibrosis (silicosis) and lung cancer.
65	Sulfotep	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
66	Temephos	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.

PAGE	TOPIC	CHANGES	RATIONALE
67	Thallium soluble compounds, as Tl	Change of WES-TWA to 0.02mg/m^3	To protect for gastrointestinal damage and peripheral neuropathy.
67	Tin, metal	Entry removed and replaced with new entry 'Tin dust, tin oxides, and inorganic compounds (except SnH_4 and In_2O_5Sn) as Sn'	
67	Tin, Oxide and inorganic compounds, except SnH_4, as Sn	Entry removed and replaced with new entry 'Tin dust, tin oxides, and inorganic compounds (except SnH_4 and In_2O_5Sn) as Sn'	
67	Tin, Organic compounds, as Sn	Entry removed and replaced with 'Tin, organic compounds including mono- and di-methyltin and n-butyltin (not otherwise classified), as Sn'	
67	Tin dust, tin oxides, and inorganic compounds (except SnH_4 and In_2O_5Sn) as Sn	Introduction of WES-TWA of 2mg/m^3	To protect for acute irritation effects and pneumoconiosis (stannosis).
67	Tin, organic compounds including mono- and dimethyltin and n-butyltin (not otherwise classified), as Sn	Introduction of WES-TWA of 0.05mg/m^3 Introduction of WES-STELs of 0.1mg/m^3 (non-irritant compounds) and 0.02mg/m^3 (irritant compounds) Introduction of 'skin' notation	To protect for irritation effects, immune system effects, and nephro- and neurotoxicity. Some organic ligands may be sensitisers. Skin absorption.
67	Tin, tri- and tetra-methyltin compounds, as Sn	Introduction of WES-TWA of 0.005mg/m^3 Introduction of WES-STEL of 0.02mg/m^3 Introduction of 'skin' notation Introduction of 'oto' notation for trimethyltin compounds	To protect for immune system effects, and nephro- and neurotoxicity. Some organic ligands may be sensitisers. Skin absorption. Ototoxin.
67	p-Toluidine	Change of WES-TWA to 1ppm Change of WES-STEL to 2ppm	To protect for methaemoglobinaemia, and irritation effects.
67	Tributyl phosphate	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
68	Trichloroacetic acid	Removal of WES-TWA Introduction of WES-STEL of 0.2ppm (1.4mg/m^3) Introduction of 'ifv' notation	To protect for eye and upper respiratory tract irritation. The Inhalable Fraction and Vapour (ifv) notation is used when a material exerts sufficient vapour pressure such that it may be present in both particle and vapour phases, with each contributing to a significant portion of exposure.

PAGE	TOPIC	CHANGES	RATIONALE
68	1,1,2-Trichloroethane	Change of WES-TWA to 1ppm Change of WES-STEL to 2ppm	To protect against liver damage, and eye and upper respiratory tract irritation.
68	Triethanolamine	Change of WES-TWA to 1mg/m^3	To protect for irritant effects.
69	Trimethylamine	Change of WES-TWA to 2ppm Removal of WES-STEL Introduction of WES-Ceiling of 5ppm	To protect for eye and respiratory tract irritation and potentially, visual disturbances.
69	Triorthocresyl phosphate	Change of WES-TWA to 0.02mg/m^3 Introduction of 'bio' notation Introduction of 'ifv'notation	To protect for central and peripheral neurotoxicity and cholinesterase inhibition. Exposure can also be estimated by biological monitoring. The Inhalable Fraction and Vapour (ifv) notation is used when a material exerts sufficient vapour pressure such that it may be present in both particle and vapour phases, with each contributing to a significant portion of exposure.
69	Triphenyl phosphate	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.
70	Vinyl toluene	Change of WES-TWA to 20ppm Change of WES-STEL to 40ppm	To protect for eye and mucus membrane irritation.
70	Vinylidene chloride (1,1-Dichloroethylene)	Change of WES-TWA to 2ppm Change of WES-STEL to 5ppm	To protect for liver and kidney effects, and neurotoxicity.
71	Xylene (o-, m-, p-isomers)	Introduction of a 'bio' notation	Exposure can also be estimated by biological monitoring.

Obligations and rights under the Health and Safety at Work Act 2015 (HSWA) and Health and Safety at Work (General Risk and Workplace Management) Regulations 2016

What are the obligations of a person conducting a business or undertaking (PCBU)?

PCBUs must ensure the health and safety of workers doing work for the PCBU and to ensure the health and safety of others whose work is influenced or directed by the PCBU.

PCBUs must also ensure that the health and safety of other persons is not put at risk from the work carried out as a part of the PCBU's business or undertaking.

To achieve this, PCBUs must (so far as is reasonably practicable):

- identify hazards that might give rise to risks to health and safety
- eliminate risks to health and safety
- minimise risks that are not reasonably practicable to eliminate
- provide and maintain a work environment that is without risks to health and safety
- provide and maintain safe plant and structures
- provide and maintain safe systems of work
- ensure the safe use, handling and storage of substances
- provide adequate and accessible facilities for the welfare of workers doing work for the PCBU
- provide the information, training, instructions or supervision necessary to protect all persons from risks arising from work carried out as a part of the conduct of the business or undertaking
- ensure that the health of workers at the workplace is monitored
- ensure that the conditions at the workplace are monitored
- provide adequate and accessible first aid facilities for workers
- provide suitable personal protective equipment and clothing for workers and other persons and ensure that it is used
- engage with workers so workers have a reasonable opportunity to raise health and safety issues and to contribute to the decision-making process.

Do workers and others have obligations and rights?

Yes. Workers and other persons at a workplace are required to take reasonable care to ensure their health and safety and the health and safety of others who are there. This includes considering both the things they do and the things they omit to do (such as not using safety equipment or appropriate exposure controls). They are also required to comply with any reasonable health and safety instruction given by the PCBU.

Workers are also required to co-operate with any reasonable health or safety policy or procedure of the PCBU.

Although it is the PCBU's overall responsibility to ensure a safe working environment, workers do have a responsibility to use the exposure controls and safety equipment provided, and to wear protective clothing as appropriate.

Workers and others should also report to the PCBU any risks or incidents they become aware of so the PCBU can investigate and put safeguards in place.

Workers are entitled to receive, free of charge, protective clothing and equipment if this is necessary to protect them from health and safety risks in the workplace.

Workers are entitled to:

- receive information, supervision, training, and instruction appropriate to the work they are doing, the plant they are using, and the substances they are handling so they can do their job in a safe and healthy manner
- wear their own suitable personal protective clothing and equipment, but the PCBU must ensure that any such clothing and equipment is suitable
- have access to the results of exposure monitoring (where such monitoring is required by regulations) at the workplace where they may be, or may have been exposed to the health hazard, provided that the exposure monitoring results do not contain any information that identifies or discloses anything about an individual worker
- be provided with a copy of any health monitoring report relating to health monitoring of the worker
- receive reasonable opportunities to participate in workplace health and safety

For further information on health and safety rights and responsibilities in the workplace visit: worksafe.govt.nz

Part One

WORKPLACE EXPOSURE STANDARDS FOR AIRBORNE CONTAMINANTS

1.0 Explanation of workplace exposure standards (WES)

IN THIS SECTION:

1.1 Introduction

Target audience

The Workplace Exposure Standards (WES) are intended to be used as guidelines for health risk management.

PCBUs and people with duties under the Health and Safety at Work Act 2015 (HSWA) and the Hazardous Substances and New Organisms Act 1996 (HSNO Act) may use this page as a reference; but it is recommended that specialist advice is sought prior to engaging in monitoring programmes or exposure control.

It is not recommended that untrained persons use WES to assess health risks. Professional judgement is required in making decisions regarding safe levels of exposure to chemicals in the workplace.

Legal requirements

WES are an important part of risk management for substances hazardous to health in the workplace. Where hazardous or toxic substances exist in the workplace, they may pose a risk to workers and others who are exposed to them. If a PCBU is unable to successfully eliminate exposure to hazardous or toxic substances at the workplace, they are required to minimise the risk from exposure, so far as is reasonably practicable as per s 30 of the Health and Safety at Work Act 2015.

WES are guidance values provided by WorkSafe that refer to the airborne concentration of substances at which it is believed that nearly all workers can be repeatedly exposed day after day without coming to harm.

Monitoring exposure using WES is a way for PCBUs to identify, assess or confirm risk from exposure as well as identify appropriate control measures to minimise risk. PCBUs can assess the results of their exposure monitoring in respect of particular hazardous or toxic substances against the specified WES to provide an indication of the likelihood of exposure resulting in adverse health impacts.

PRESCRIBED EXPOSURE STANDARDS (PES)

WorkSafe also has PES which are prescribed workplace exposure standards or a biological exposure index that has the purpose of protecting persons in a workplace from harm to health. Unlike WES which are guidance values only, PES must not be exceeded and it is an offence to exceed a PES. PES are prescribed in:

a. Regulations

b. A safe work instrument, or

c. the Hazardous Substances and New Organisms Act 1996 as a control under section 77 or 77A, or an exposure limit under section 77B or a group standard approval issued under section 96B.

Regulations 29, 30 and 32 of the GRWM Regulations provide that a PCBU commits an offence by exceeding a PES, failing to undertake exposure monitoring where they are uncertain on reasonable grounds about whether the concentration exceeds a PES, or where the duties relating to exposure monitoring of PES are not complied with. Those substances that have a PES (in addition to a WES) are noted in Table 4 and Table 5 of this guidance.

As noted above, regulation 32 of the GRWM Regulations provides that when exposure monitoring is required, by regulations, to be carried out, certain duties must also be complied with. This includes that a PCBU must ensure that the results of exposure monitoring are readily accessible to any person at the workplace who may be, or may have been, exposed to the health hazard provided that no information that identifies, or discloses anything about an individual worker is disclosed. The Privacy Act 2020 principles apply to any personal information (information about an identifiable individual) that is collected about a worker. The individual must, among other things, be aware of the fact that the information is being collected, the purpose for collection and the intended recipients.

Regulation 8 of the GRWM Regulations requires a PCBU to review, and as necessary revise control measures if the results of exposure monitoring carried out under regulation 30 determine that the concentration of a substance hazardous to health at the workplace exceeds a relevant prescribed exposure standard.

Limitations

Defining an exposure level that will achieve freedom from adverse health effects is the major consideration for assigning these WES. However, merely demonstrating that exposures are unlikely to exceed the WES value 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 may experience discomfort or develop occupational illness from exposure at levels below the WES.

The numerical value of two or more WES must not be used to directly compare the relative toxicity of different substances as the biological potency and toxicologic effects used to derive a WES are specific to each substance.

When interpreting the risk posed by individual substances, the documentation that supports the WES should be consulted.

When applying these WES values, it is important to understand the end-point health effects for which it is designed to protect for, and the limitations of the WES or data used to derive the value. It is good practice to consider WES values from other organisations in managing the health risk. Relevant sources of other exposure standards include the Gestis substance database, the ACGIH®, SCOEL, ECHA, DFG, DECOS, and Safe Work Australia. Access to their documentation that explains the value is necessary, rather than just adopting a number without any information as how and why it was selected.

Substances without a WES

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. As such some substances do not have WES. If a substance doesn't have a WES, this should not be taken to mean that it is safe under all conditions, and that no restriction should be placed on its use. Regardless of the substance, it is important to eliminate or minimise the concentration of airborne substances as far as is reasonably practicable.

Substances with a WES-TWA but without a WES-STEL

To provide an upper limit on short-term exposures, an excursion limit (EL) may be applied for substances that have a WES-TWA, but no WES-STEL or WES-Ceiling. Before applying an EL, further information should be obtained to help inform whether or not doing so is an appropriate approach, rather than assuming it to be appropriate for all substances. Such information may include acute toxicological data or the existence of short-term exposure limits from other jurisdictions.

Routes of entry

Hazardous or toxic substances may enter the body following inhalation, ingestion or skin absorption. But in occupational settings, it is most often the inhalation aspect that is most important, in terms of exposure however this is substance dependent.

Substances listed with a skin notation (skin) are known to have potential for significant skin absorption particularly from liquid, but potentially also from vapour. 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 inhalation (such as might be estimated from the airborne level). This is further discussed in the section on skin absorption (Section 1.9).

Exposure to airborne substances is usually monitored 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 guideline levels is located in the second part of this document.

Definitions

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

1.2 Application of WES

Personal sampling

Monitoring workers' exposure will involve comparison of results against Workplace Exposure Standards and Biological Exposure Indices.

Workplace exposure standards (WES) are values that refer to the airborne concentration of substances at which it is believed that nearly all workers can be repeatedly exposed 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.

In all instances, workplace exposure standards relate to exposure that has been measured by personal monitoring using procedures that gather air samples in the worker's breathing zone. The breathing zone is defined as a hemisphere of 300mm radius extending in front of the face and measured from the midpoint of an imaginary line joining the ears.

Substances with multiple WES (for different periods of exposure) will require monitoring for those specific periods. For example if a substance has a WES-TWA (time weighted average) then exposure for the whole shift needs to be assessed. This does not necessarily mean exposure has to be measured over the whole shift, but if exposure will vary, full shift sampling will provide the most useful data for the risk assessment. If the substance also has a WES-STEL (short term exposure limit), exposure over 15-minutes needs to be assessed.

It is important to ensure results are measured and calculated over appropriate time frames when comparing to a specific WES, and that WES are adjusted accordingly for extended workshifts (see section 1.3).

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 each WES was set, the biological basis for assigning the WES varies. Some WES are designed to prevent the development of ill health after long-term exposure (WES-TWA), others to reduce the possibility of acute effects (WES-Ceiling, WES-EL, WES-STEL).

Assessing exposure

Assessing workers' exposure relies on good sampling strategy in addition to the correct sampling equipment and interpretation of results.

WorkSafe recommends that professional help be sought in the development and implementation of a sampling strategy and interpretation of results (for example, from an appropriately qualified occupational hygienist).

When carrying out exposure assessments, assessing health risks, or assessing the need for, or effectiveness of controls, the assessor should have competence in:

- the risk assessment process
- the tasks, processes or exposures being assessed
- development of sampling strategy
- selection and use of sampling equipment and sampling media
- sampling methods
- interpretation of data
- criteria on which WES are based
- relevance and application of statistical analysis of exposure data.

Assessor competency should be maintained by subscribing to a programme of continuous professional development. Such programmes are available to members of professional bodies such as the New Zealand Occupational Hygiene Society (NZOHS)

An assessor could equally develop their own programme that covers on-going training (including refresher training), training or recruitment that addresses lacks of competence in a particular areas, attendance at conferences, meetings or webinars etc.

Assessors not yet fully competent to operate independently should consider being mentored by a fully competent assessor such as a full member of the NZOHS. Mentoring involves meetings between the mentor and mentee that take the form of a professional discussion around personal development, current projects and the challenges faced. One of the aims is for the mentor to get the mentee to think about how they might approach a problem, what other things they might encounter and how they might deal with them. Mentoring arrangements should be documented to help ensure their effectiveness.

WorkSafe encourages PCBUs to use the services of consultants who are listed on the HASANZ Register

HASANZ is the Health and Safety Association of New Zealand and is the umbrella organisation representing workplace health and safety professions in New Zealand. The register lists independent consultants and in-house professionals – generalists and specialists – who meet the competency standards of an association that is a full member of HASANZ. For those offering occupational hygiene services, their association is the NZOHS.

By selecting a consultant from the HASANZ Register, a PCBU can have confidence that they are selecting a person who is competent to undertake the services for which they are listed.

Good communication skills, as well as the systematic collection of data and information are essential and reports should present the results and any recommendations clearly and in a style that the PCBU will understand.

The assessor must have a clear understanding of the limitations of their own competencies.

Sampling strategy

Sampling strategy will usually include identifying groups of workers for whom risk and exposure profiles are similar. These groups are called SEGs (similar exposure groups). Choosing a representative unbiased subsample of the SEG should be sufficient for assessing exposure and risk for the whole SEG.

Most worker exposure monitoring will be occasional in that the workers will not wear monitoring equipment all the time (with some exceptions (for example, explosive gas meters), which are usually used for safety risk management rather than health risk). The regularity of worker exposure monitoring will depend on the objectives and outcomes of the risk identification and analysis. For example, if the risk identification or analysis indicates that exposure can vary considerably from day to day, then monitoring may need to occur on a more regular basis than an exposure that does not change considerably over time, or an exposure that is well managed.

Monitoring should occur when there are any changes in processes or activities that result in, or may result in, a change to exposure, or if it is not certain whether or not the airborne concentration exceeds the Workplace Exposure Standard (WES) or presents a health risk.

Variation in exposure

Exposure levels are commonly variable, even in work that is regular and consistent. Variation in worker exposure arises from variation in work activities, control methods and environmental conditions.

Due to this variation, exposure measured on a single day may not reflect exposure on other days. Even samples from multiple days may not reflect the true variation in exposure that may occur over the long term. With this in mind, the monitoring strategy must be designed to provide sufficient measurements to reflect the risk to the worker from the variation in exposure.

It is very rare for all exposures for a worker to be measured all the time. Frequently only one or two shifts will be sampled and this data will be used to make judgements about exposures over many months or years. If the worker is exposed every day for five years, and their exposure is assessed once a year, then five days of data is being used to make judgements about 1250 days of exposure. Various methods are available for determining an appropriate number of samples to account for variation. Methods include:

- at least one employee in five from a properly selected SEG (UK Health and Safety Executive HSG173 (2006)[1]
- a calculated number of samples based on previous data, using t-statistics and co-efficient of variation (source W501 OH Learning, Measurement of Hazardous Substances, 2009)[2]
- methods of Rappaport, Selvin and Roach (1987) based on the number of samples needed to test the mean exposure of a lognormal distribution of exposures against an exposure standard (source W501 OH Learning, Measurement of Hazardous Substances, 2009)[2]
- South African Mines Occupational Hygiene Programme – sample 5% of workers in an SEG[3]

[1] UK Health and Safety Executive HSG173 Monitoring strategies for toxic substances (2006).

[2] OH Learning W501 Measurement of Hazardous Substances. www.OHlearning.com (2009).

[3] South African Mines Occupational Hygiene Programme codebook (SAMOHP) (2002).

- American Industrial Hygiene Association suggests 6–10 samples are sufficient to give a picture of an exposure profile. In respect to the minimum number of samples to be collected, fewer than six samples in any one SEG leaves a great deal of uncertainty about the exposure profile (AIHA 2015).[4]
- European Standard EN 689:2018 'Workplace exposure – Measurement of exposure by inhalation to chemical agents – Strategy for testing compliance with occupational exposure limits'.

Statistical analysis of sampling results

Multiple exposure samples generally allow for better understanding of the variation in exposure, and thus provide more detailed information for the risk assessment.

Where multiple samples are taken, application of appropriate statistical analysis to sampling results can be valuable in:

- assessing confidence that the measured results represent the 'true' exposure profile (the profile you would see if you were to measure the exposure every shift, and you were to measure all workers in the SEG)
- interpreting whether exposures are likely to exceed the WES
- managing uncertainties in exposure assessment and health risk assessment.

Application of appropriate statistical analysis to sampling results is important in order to assess how closely the results represent the 'true' exposure profile and can be used to assess the likelihood that workers in that similar exposure group will exceed the designated WES, how close the true exposure is to the WES and assist in determining if there is risk that needs further control.

Useful resources for statistical analysis of occupational hygiene samples include:

- 'IHStats' spreadsheet developed by the American Industrial Hygiene Association
- Expostats: statistical tools for the interpretation of industrial hygiene data
- BWSTAT: online tool developed by the Belgian Society for Occupational Hygiene for statistical analysis of exposure monitoring data

Using WES to assess risk

When evaluating exposure in relation to a WES, the following points must be considered:

- How representative is the sampling programme in regard to variation in exposure, and how do the results represent the 'true' exposure profile?
- Variability of exposure means that occasional high results can occur even where the exposure is generally well controlled.
- Comparison of exposure monitoring data with the designated WES level does not guarantee that all workers are protected from discomfort or ill health due to individual susceptibility.

The above considerations show that using exposure monitoring data to assess health risk is rarely a straightforward process of comparing a sample result, or an average, to a WES. Various organisations have developed guidelines to address the issue of how to assess health risk using a WES to determine whether further control of exposure needs to occur.

Care should be taken to ensure the sampling strategy and subsequent analysis follow the selected method closely as they all have conditions that must be met and can use slightly different statistical criteria.

[4] The American Industrial Hygiene Association (AIHA) A Strategy for Assessing and Managing Occupational Exposures, 4th edition (2015).

Examples of these methods and guides are:

- BOHS[5] 'Testing Compliance with Occupational Exposure Limits for Airborne Substances'
- AIHA[4] – A Strategy for Assessing and Managing Occupational Exposures, 4th edition
- AIOH Occupational Hygiene Monitoring and Compliance Strategies
- ICMM[6] provides guidance on rating exposures
- European Standard EN 689:2018 Workplace exposure – Measurement of exposure by inhalation to chemical agents – Strategy for testing compliance with occupational exposure limits

1.3 Adjustment of WES for extended workshifts

Workplace Exposure Standard Time Weighted Averages (WES-TWA) are derived on an eight hour work day and 40 hour work week. When shifts are longer than this, either over a day or a week, the WES-TWA needs to be adjusted to account for the longer period of exposure and shorter recovery time.

Various models are available to make the adjustment and each may result in a different adjusted WES.

The selection of an appropriate model is dependent on various factors such as: ease of use; availability of an adjustment model for a specific WES; and the availability of relevant toxicology and pharmacokinetics data for pharmacokinetic models. A useful document for discussion on adjustment models is the Australian Institute of Occupational Hygienists' Position Paper on 'Adjustment of Workplace Exposure Standards for Extended Workshifts'

A simple method to use is the Brief and Scala Model. A criticism of the model is that it is generally considered to be excessively protective for some substances. Other models include web based tools such as the IRSST 'Quebec' model. A summary of these models is given below.

When a WES-Ceiling or WES-STEL has been assigned, no correction for shift patterns is required. The exposure level for the appropriate period (instant or 15 minutes) is compared directly with the Ceiling or STEL.

A. BRIEF AND SCALA MODEL

An adjustment is made to the WES by applying the following formula:

Daily exposure adjustment:

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

Where h = hours worked per day

Seven day work week adjustment:

$$\text{Adjusted WES-TWA} = \frac{40 \times (168\text{-}h) \times \text{WES-TWA}}{128 \times h}$$

Where h = hours worked per week

[5] British Occupational Hygiene Society, *Testing Compliance with Occupational Exposure Limits for Airborne Substances*.

[6] International Council on Mining and Metals (ICMM) Good Practice Guidance on Occupational Health Risk Assessment (2007).

Example of adjusting for an extended work shift using the Brief and Scala model

Substance: Isopropyl alcohol – WES-TWA: 400ppm, WES-STEL: 500ppm

Work shift: 12 hours

Adjusted WES-TWA:

$$\frac{8 \times (24-12) \times 400}{16 \times 12} = 200\text{ppm (12 hour TWA)}$$

The average exposure over the 12-hour shift would be compared with the 12-hour WES-TWA standard of 200ppm. No adjustment is required for the WES-STEL.

B. IRSST MODEL (QUEBEC MODEL)

The Quebec Institut de Recherche Robert-Sauve en Sante et en Securite du Travail (IRSST) has developed a computer-based tool to calculate an adjusted TWA. The model makes adjustments of the Quebec WES (called PEVs) as defined in the Quebec Regulation Respecting Occupational Health and Safety (RROHS). Some of the Quebec WES differ from New Zealand. Although adjustment factors are provided in the model, these are based on the critical health endpoints used to derive their WES. Before applying the Quebec Model it should be confirmed that the adjustment classification in the Quebec Model for the selected substance is appropriate for the health endpoint(s) used to select the New Zealand WES. The model is available at: www.irsst.qc.ca/en/_outil_100011.html

C. AIOH WES SHIFT ADJUSTMENT TOOL

The AIOH have developed the WES Shift Adjustment Tool which has been based on the well accepted technical information currently available. The tool allows shift adjustment based on either the Brief and Scala Model or the Quebec Model depending on how well hours worked and shift patters are understood. The AIOH tool applies the Quebec Model using the critical health endpoints for the Australian WES. Therefore, it should be confirmed that the health endpoint(s) used to select the Australian WES is the same as the New Zealand WES before applying the adjustment factor to the New Zealand WES. The tool AIOH is available at: https://www.aioh.org.au/media/2021/05/aioh-adjustment-v018-swa-40.xlsm

D. WESTERN AUSTRALIA DEPARTMENT OF MINERALS AND ENERGY MODEL

In this guideline various exposure reduction factors are applied depending on the timeframe for response (immediate, medium or long term), health effect (acute, chronic, irritation, narcosis) and shift length. The appropriate reduction factor is selected and applied to the WES. The model is available at: www.dmp.wa.gov.au/Documents/Safety/MSH_G_AdjustAtmosphericExposureStd.pdf

E. PHARMACOKINETIC MODELS

There are a number of pharmacokinetic models in use. These models are based on the concept of body burden and how the biological half-life of a substance can have a significant impact on the maximum body burden for a given work schedule. They are based on ensuring that the maximum body burden for an extended work shift doesn't exceed that for an eight hour shift. These models are generally considered more accurate however, they can be very complicated and, as half-lives can vary substantially between different individuals, there are limitations.

1.4 Work load

An increase in work load can influence the uptake of a substance by increasing the lung ventilation rates and blood flow.

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. The table can be used:

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 (for example, writing, typing, small bench tool work, standing while drilling or milling small parts)	11–20	100
Moderate (for example, hammering in nails, filing, pneumatic hammering, walking 3.5–5.5km/h)	20–31	150
High (for example, carrying heavy loads, shovelling, digging, pushing or pulling heavy cart, walking 5.5–7.0km/h)	31–43	200
Very high (for example, working with axe, intense shovelling or digging, climbing ladder, stair or ramp, walking in excess of 7km/h)	43–56	250

TABLE 1:
Lung ventilation rates impacted by workload

1.5 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^3). WES for gases and vapours are expressed in ppm, with the units mg/m^3 also listed. In the case of particulates, the concentration is given in mg/m^3. The following equation, which is based on a temperature of 25°C and a pressure of 760 torr is used to convert ppm to mg/m^3:

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

1.6 Mixed exposures

Generally, WES are listed for a single substance or a range of compounds. In some instances, a WES has been set for a group of substances (for example, 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.

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 its 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. An understanding of the health basis on which the WES has been set is essential for determining if the substances have independent health effects.

An example is toluene-2,4-diisocyanate and toluene. The toluene-2,4-diisocyanate WES is based on minimising the potential for respiratory tract effects and sensitisation. The toluene WES is based on minimising the potential for central nervous system depression.

Additive effects

If two or more hazardous substances have similar toxicological effects on the same target organ or system, their combined effect should be considered.

In this case the combined exposures need to be compared against the WES of the mixture, as well as each individual substance against its specific WES.

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.

1.7 Aerosols

Aerosols encountered in the workplace include airborne particulates (this includes dusts and fumes) and mists.

Dusts are discrete particles suspended in air, originating from the attrition of solids or the stirring up of powders or other finely divided materials. 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 1μm. They may be formed by both thermal mechanisms (for example, condensation of volatilised solids, or incomplete combustion) and chemical processes (for example, 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.

Aerodynamic equivalent diameter (AED)

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

Health effects of particulates

Airborne particulates are associated with a variety of adverse health effects and may have one or more of the following properties:

- infectious
- carcinogenic
- fibrogenic
- allergenic
- irritative.

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 toxic potential of a substance is influenced by a number of factors including concentration, particle size, mass, surface area and solubility.

Inhalable and respirable dust

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.

Unless otherwise stated, the WES for dusts refers to inhalable dust. The WES that apply to particulates not otherwise classified apply to particulates that (i) do not have a specified WES, (ii) are insoluble or poorly soluble in water (or, preferably, in aqueous lung fluid if data are available), and (iii) have low toxicity (that is, are not cytotoxic, genotoxic, or otherwise chemically reactive with lung tissue, and do not emit ionising radiation, cause immune sensitisation, or cause toxic effects other than by inflammation or the mechanism of 'lung overload').

Even biologically inert, insoluble, or poorly soluble particulates may have adverse effects and it is recommended that airborne concentrations should be kept below 3mg/m^3 for respirable particulates and 10mg/m^3 for inhalable particulates, until such time as a WES is set for a particular substance.

INHALABLE DUST

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

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

TABLE 2: Collection efficiency curve for inhalable dust

Where d is the equivalent aerodynamic diameter of the particle in μm.

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 30µm. 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 3640–2009: Workplace Atmospheres – Method for Sampling and Gravimetric Determination of Inhalable Dust*.[7]

[7] Standards Australia, *AS 3640:2009. Workplace Atmospheres: Method for Sampling and Gravimetric Determination of Inhalable Dust*. Standards Australia, Sydney, (2009).

The use of either of two personal sampling heads is recommended: the United Kingdom Atomic Energy Authority (UKAEA) sampling head or the IOM inhalable dust sampling head developed by the UK Institute of Occupational Medicine, Edinburgh.

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 2985–2009: Workplace Atmospheres – Method for Sampling and Gravimetric Determination of Respirable Dust.[8]

Care is advised in the selection of cyclone sampling heads used for the determination of respirable dust. Recent research indicates that oversampling may occur with some sampling devices used at the historically recommended flow rates. It is strongly recommended that hygienists conducting this work obtain advice from the manufacturers or suppliers of such equipment to inform their equipment selection decisions.

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

d	0	1	2	3	4	5	6	7	10	14	16
Respirability %	100	100	97	80	56	34	20	11	2	0.2	0.1

TABLE 3: Collection efficiency curve for respirable dust

Where d is the equivalent aerodynamic diameter of the particle in μm.

1.8 Carcinogens

For cancers induced by exposure to airborne 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.

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 known, presumed, or suspected human carcinogens have this notation.

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

Carcinogenicity Category 1 (formerly 6.7A) – substances that are known or presumed human carcinogens

The placing of a chemical in Category 1 is done on the basis of epidemiological and/or animal data. An individual chemical may be further distinguished as known or presumed to have carcinogenic potential for humans.

Based on strength of evidence together with additional considerations, such evidence may be derived from human studies that establish a causal relationship between human exposure to a chemical and the development of cancer (known human carcinogen). Alternatively, evidence may be derived from animal experiments for which there is sufficient evidence to demonstrate animal carcinogenicity (presumed human carcinogen). In addition, on a case by case basis,

[8] Standards Australia, *AS 2985:2009. Workplace Atmospheres: Method for Sampling and Gravimetric Determination of Respirable Dust*. Standards Australia, Sydney, (2009).

scientific judgement may warrant a decision of presumed human carcinogenicity derived from studies showing limited evidence of carcinogenicity in humans together with limited evidence of carcinogenicity in experimental animals.

Carcinogenicity Category 2 (formerly 6.7B) – substances that are suspected human carcinogens

The placing of a chemical in Category 2 is done on the basis of evidence obtained from human and/or animal studies, but which is not sufficiently convincing to place the chemical in Category 1. Based on strength of evidence together with additional considerations, such evidence may be from either limited evidence of carcinogenicity in human studies or from limited evidence of carcinogenicity in animal studies.

Substances that are not covered by HSNO legislation, but are carcinogenic to humans, have been noted as such.

Wherever practicable, 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 GRWM[9] must be strictly applied.

Where appropriate, exposure 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.

1.9 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 substances.

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 WES table (table 4) with a ‘skin’ notation. Where a class or a group of substances are identified with a ‘skin’ notation, that notation may or may not apply to every substance in the group. Risk assessment for these substances should consider if skin absorption is a route of entry requiring control.

1.10 Sensitiser

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. It is uncommon to become sensitised to a compound after just a single reaction to it.

[9] Regulation 6, which applies to the management of risks that are not practicable to eliminate – the PCBU must minimise risks to health and safety and implement control measures. Minimisation must be achieved by one or more of the following: substitution for a lesser risk, isolation of the hazard giving rise to the risk, or implementing engineering control. If a risk remains, the PCBU must minimise the remaining risk by implementing administration controls and only after the above strategies have been implemented, and a risk still remains, may the remaining risk be minimised by ensuring the provision and use of personal protective equipment.

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, exposure route, method of use, and the individual worker.

Substances that are considered to have potential for sensitisation are identified in the WES table (table 4) with a 'sen' notation (not specified), 'rsen' notation (respiratory sensitiser), or 'dsen' (dermal sensitiser).

1.11 Simple asphyxiants

Some gases and vapours, when they are present in the air in significant concentrations, behave as asphyxiants by reducing the concentration of oxygen.

The oxygen content of air should be maintained at 19.5–23.5% under normal atmospheric conditions to manage health risks associated with oxygen.

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 workers. Substances that are considered asphyxiants are identified with a 'sa' (simple asphyxiant) or 'sax' (simple asphyxiant – may present an explosion hazard) notation.

1.12 Ototoxins

Some substances can cause hearing loss either in conjunction with noise exposure, or without concurrent noise exposure. These substances are known as ototoxins and they can affect the cochlea and/or the auditory neurological pathways. They present a risk via the inhalation route of exposure, and some present a risk via skin absorption.

Workplace Exposure Standards have not been adjusted to reflect risk of hearing impairment. As such a cautious approach should be applied when using WES for a substance that has ototoxic potential. In addition risk is likely to be higher if there is exposure to multiple ototoxins. As a combination of exposure to noise and ototoxins has an additive or possibly synergistic effect on risk of hearing loss, occupational noise management programs should consider ototoxin exposure management.

Some aromatic and aliphatic hydrocarbon solvents are known ototoxins and include acrylonitrile, alcohol, carbon disulphide, ethyl benzene, heptane, n-hexane, perchloroethylene, styrene, toluene and trichloroethylene. Other ototoxins include arsenic, carbon monoxide, cobalt, hydrogen cyanide, lead, mercury, organophosphate pesticides, trimethyl tin, manganese and mercury. Substances that are considered to have potential for ototoxicity have an 'oto' notation.

2.0
WES values

IN THIS SECTION:

2.1 Table of WES values

The following section is set by WorkSafe.

Reference key for workplace exposure standards

KEY	DESCRIPTION
bio	Exposure can also be estimated by biological monitoring
carcinogen category 1	Known or presumed human carcinogen
carcinogen category 2	Suspected human carcinogen
CAS #	CAS Number, a unique numbering identifier is assigned by the Chemical Abstracts Service Registry to each individual chemical
dsen	Dermal sensitiser
f	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
ifv	The Inhalable Fraction and Vapour (ifv) notation is used when a material exerts sufficient vapour pressure such that it may be present in both particle and vapour phases, with each contributing to a significant portion of exposure
mg/m³	Milligrams of substance per cubic metre of air
om	Sampled by a method that does not collect vapour
oto	Ototoxin
p	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
PES	Prescribed exposure standard – a workplace exposure standard or a biological exposure index that has the purpose of protecting persons in a workplace from harm to health and that is prescribed in Regulations or in a Safe Work Instrument
ppm	Parts of vapour or gas per million of air by volume
r	The value for respirable dust
rsen	Respiratory sensitiser
sa	Simple asphyxiant
sax	Simple asphyxiant – may present an explosion hazard
sen	Sensitiser
skin	Skin absorption
w	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. Exposure assessment of welding fume should be based on measurement of known or expected components in welding fume which would include metal constituents as well as shielding gases and contaminants produced during combustion of surface coatings and cleaning products, where present

KEY	DESCRIPTION
†	This is an interim WES and WorkSafe considers it may not be protective for all workers. As such, caution should be applied in using the WES for health risk assessment. WorkSafe intends to review or change the WES in the future for the following substances: – Diethyl sulphate: Interim WES-TWA of 0.01ppm. Propose to review WES again in the future – Flour dust: Interim WES-TWA of 1mg/m³. Propose to change to WES-TWA of 0.2mg/m³ in the year 2024 – Hydrogen sulphide: Interim WES-TWA of 5ppm and WES-STEL of 10ppm. Propose to change to WES-TWA of 1ppm and WES-STEL of 5ppm in the year 2024 – Nitrogen dioxide: Interim WES-TWA of 1ppm. Propose to review WES again in the future – Vanadium, as V: Interim WES-TWA of 0.05mg/m³, as V for V and its inorganic compounds, except CI pigment yellow 184. Propose to review WES again in the future – Vinyl acetate: Interim WES-TWA of 5ppm and WES-STEL of 10ppm. Propose to review the WES again in the future – Wood dust, softwood: Interim WES-TWA of 2mg/m³. Propose to change to WES-TWA of 1mg/m³ in the year 2024 – Isocyanates, all, (as -NCO): Interim WES-TWA of 0.02mg/m³ and WES-STEL of 0.07mg/m³. Propose to change in 2024 to: WES-TWA of 0.0001mg/m³ WES-STEL of 0.0005mg/m³ with Skin notation – Titanium dioxide: Interim WES-TWA of 10mg/m³. Propose to review in 2024 given publication of new information from cited sources – Phosphine: Interim WES-TWA of 0.3ppm and WES-STEL of 1ppm. Propose to change to WES-TWA of 0.05ppm and WES-STEL of 0.2ppm in 2024

Unless otherwise stated, WES values in the following table for solid particles refer to the inhalable fraction, as opposed to the respirable fraction.

TABLE 4: Workplace exposure standards

A		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
Acetaldehyde	[75-07-0]					20	36	carcinogen category 2	2020
Acetic acid	[64-19-7]	10	25	15	37				
Acetic anhydride	[108-24-7]	0.1	0.42	0.2	0.84				2023
Acetone	[67-64-1]	500	1185	1000	2375			bio	
Acetonitrile	[75-05-8]	40	67	60	101			skin	[2023]
Acetylene	[74-86-2]							sax	
Acetylene dichloride (1,2-Dichloroethylene)	[540-59-0]	200	793						
Acetylene tetrabromide	[79-27-6]	1	14						
Acetylsalicylic acid (Aspirin)	[50-78-2]		5						
Acrolein	[107-02-8]	0.02	0.05	0.05	0.12				2023
Acrylamide	[79-06-1]		0.0015					carcinogen category 1; skin; dsen	2019
Acrylic acid	[79-10-7]	2	5.9					skin; dsen	
Acrylonitrile (Vinyl cyanide)	[107-13-1]	0.05	0.1					carcinogen category 1; skin; dsen; oto	2019
Allyl alcohol	[107-18-6]	2	4.8	4	9.5				
Allyl chloride	[107-05-1]	1	3	2	6			carcinogen category 2	
Allyl glycidyl ether (AGE)	[106-92-3]	0.25	1.2	0.5	2.4			skin; dsen	2020
Aluminium metal and insoluble aluminium compounds (including pyro powder, aluminium oxide, and aluminium welding fumes), as Al	[1344-28-1] [7429-90-5]		1(r)						2023
Aluminium, Alkyls (not otherwise classified) (as Al)								WES-TWA for aluminium alkyls (not otherwise classified), as Al, of 2mg/m³ removed as relevant health-based limits have not been set or have been revoked	2023

A		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Aluminium, Soluble salts (as Al)								WES-TWA for soluble salts of aluminium, as Al of 5mg/m³ removed as relevant health-based limits have not been set or have been revoked	[2022]
3-Amino-1,2,4-triazole (Amitrole)	[61-82-5]		0.2						
2-Aminoethanol (Ethanolamine)	[141-43-5]	0.2	0.5	0.2	0.5				2023
2-Aminopyridine	[504-29-0]	0.5	2						
Amitrole (3-Amino-1,2,4-triazole)	[61-82-5]		0.2						
Ammonia, Anhydrous	[7664-41-7]	25	17	35	24				[2023]
Ammonium chloride fume	[12125-02-9]		10		20				
Ammonium perfluorooctanoate	[3825-26-1]		0.1					carcinogen category 2; skin	
Ammonium sulphamate	[7773-06-0]		10						
Amosite (see Asbestos)									
n-Amyl acetate	[628-63-7]	100	532						[2023]
sec-Amyl acetate	[626-38-0]	125	665						
Aniline and homologues	[62-53-3]	1	4	2	8			carcinogen category 2; skin; dsen	2020
o-Anisidine	[90-04-0]	0.1	0.5					carcinogen category 2; skin	
p-Anisidine	[104-94-9]	0.1	0.5					carcinogen category 2; skin	
Antimony and compounds, as Sb	[7440-36-0]		0.5						
Antimony hydride (Stibine)	[7803-52-3]	0.1	0.51						
Antimony trioxide	[1309-64-4]		0.1					carcinogen category 2	2019
Argon	[7440-37-1]							sa	

A		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Arsenic and soluble compounds, as As	[7440-38-2]		0.001					carcinogen category 1; oto	2020
Arsine	[7784-42-1]	0.05	0.16						
Asbestos (all forms)			0.1 asbestos fibres per millilitre of air, averaged over an 8-hour period					confirmed carcinogen [Regulation 9(1) of the Health and Safety at Work (Asbestos) Regulations 2016 (the 'Asbestos Regulations') requires PCBUs with management or control of a workplace to ensure that exposure of a person at the workplace to airborne asbestos is eliminated so far as is reasonably practicable. If it is not reasonably practicable to eliminate exposure to airborne asbestos, exposure must be minimised so far as is reasonably practicable. Regulation 9(2) of the Asbestos Regulations requires PCBUs with management or control of a workplace to ensure that the airborne contamination standard for asbestos is not exceeded at the workplace (however, in relation to an asbestos removal area where class A asbestos removal work is being carried out, the regulations impose a more stringent standard). These requirements work together to ensure that there is a limit to the amount of asbestos that is permitted in the air of a workplace, without implying or meaning that the level delineates what is acceptable for personal exposure. Personal exposure must be eliminated or minimised so far as is reasonably practicable. The WES provided within this guide for asbestos must be applied accordingly.]	2016
Asphalt (petroleum) fumes	[8052-42-4]		0.5					skin	2023
Aspirin (Acetylsalicylic acid)	[50-78-2]		5						
Atrazine	[1912-24-9]		1						2023
Azinphos-methyl	[86-50-0]		0.2					skin; dsen; bio	

B		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Barium sulphate	[7727-43-7]		10						[2023]
Barium, soluble compounds, as Ba	[7440-39-3]		0.5						
Benzene	[71-43-2]	0.05	0.16					carcinogen category 1; skin	2020
p-Benzoquinone (Quinone)	[106-51-4]	0.1	0.44						
Benzoyl peroxide	[94-36-0]		5					dsen	
Benzyl butyl phthalate	[85-68-7]		5						
Benzyl chloride	[100-44-7]	1	5.2					carcinogen category 1	
Beryllium and compounds, as Be	[7440-41-7]		0.0002					carcinogen category 1; dsen; rsen	2018
Biphenyl (Diphenyl)	[92-52-4]	0.2	1.3						
Borates, tetra, sodium salts (Anhydrous)	[1330-43-4]		1						
Borates, tetra, sodium salts (Decahydrate)	[1303-96-4]		5						
Borates, tetra, sodium salts (Pentahydrate)	[12179-04-3]		1						
Boron oxide	[1303-86-2]		10						
Boron tribromide	[10294-33-4]					1	10		
Boron trifluoride	[7637-07-2]					1	2.8		
Bromacil	[314-40-9]	1	11					carcinogen category 2	
Bromine	[7726-95-6]	0.1	0.66	0.3	2				
Bromine pentafluoride	[7789-30-2]	0.1	0.72						

B		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Bromochloromethane (Chlorobromomethane)	[74-97-5]	200	1060						
Bromoform	[75-25-2]	0.5	5.2					skin	
1,3-Butadiene	[106-99-0]	0.05	0.1					carcinogen category 1	2019
Butane	[106-97-8]	800	1900						
Butanethiol (Butyl mercaptan)	[109-79-5]	0.5	1.8						
2-Butanone (Methyl ethyl ketone, MEK)	[78-93-3]	150	445	300	890			bio	
2-Butoxyethanol (Butyl glycol ether)	[111-76-2]	25	121					skin	[2023]
n-Butyl acetate	[123-86-4]	150	713	200	950				[2023]
sec-Butyl acetate	[105-46-4]	200	950						
tert-Butyl acetate	[540-88-5]	20	96	40	192				2023
n-Butyl acrylate	[141-32-2]	2	11	4	22			dsen	2019
n-Butyl alcohol	[71-36-3]					50	150	skin	[2023]
sec-Butyl alcohol	[78-92-2]	100	303						
tert-Butyl alcohol	[75-65-0]	20	62	80	248				2023
n-Butyl glycidyl ether (BGE)	[2426-08-6]	0.25	1.33					skin; dsen	2019
Butyl glycol ether (2-Butoxyethanol)	[111-76-2]	25	121					skin	[2023]
n-Butyl lactate	[138-22-7]	5	30						
Butyl mercaptan (Butanethiol)	[109-79-5]	0.5	1.8						

B		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Butylated hydroxytoluene (2,6-Di-tert-butyl-p-cresol)	[128-37-0]		10					dsen	
o-sec-Butylphenol	[89-72-5]	5	31					skin	
p-tert-Butyltoluene	[98-51-1]	10	61	20	121				

C		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Cadmium and compounds, as Cd	[7440-43-9]		0.004(r)					carcinogen category 1; bio	2020
Calcium carbonate	[471-34-1]		10						
Calcium chromate, as Cr	[13765-19-0]							See Chromium (VI) compounds, as Cr	2020
Calcium cyanamide	[156-62-7]		0.5					dsen	
Calcium hydroxide	[1305-62-0]		1		4				2023
Calcium oxide	[1305-78-8]		2						[2023]
Calcium silicate	[1344-95-2]		10						
Calcium sulphate (Gypsum, Plaster of Paris)	[7778-18-9]		10						
Camphor, synthetic	[76-22-2]	2	12	3	19			dsen	
Caprolactam (dust and vapour)	[105-60-2]		5		10			dsen; ifv	2022
Captafol	[2425-06-1]		0.1					skin	
Captan	[133-06-2]		5					carcinogen category 2; dsen	
Carbaryl	[63-25-2]		5					bio	

C		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Carbofuran	[1563-66-2]		0.1					bio	
Carbon black	[1333-86-4]		3					carcinogen category 2	
Carbon dioxide	[124-38-9]	5000	9000	30000	54000				
Carbon disulphide	[75-15-0]	1	3					skin; oto	2019
Carbon monoxide	[630-08-0]	20		100		200ppm		bio; oto	2022
Carbon tetrabromide	[558-13-4]	0.1	1.4						
Carbon tetrachloride (Tetrachloromethane)	[56-23-5]	0.1	0.63					carcinogen category 2; skin	
Carbonyl chloride (Phosgene)	[75-44-5]	0.02	0.08	0.06	0.25				
Carbonyl fluoride	[353-50-4]	2	5.4	5	13				
Catechol (Pyrocatechol)	[120-80-9]	5	23					skin	
Cellulose (paper fibre)	[9004-34-6]		10						
Cement (Portland cement)	[65997-15-1]		3 1(r)					dsen	2018
Chlorinated diphenyl oxide	[31242-93-0]		0.5						
Chlorine	[7782-50-5]	0.5	1.5	1	2.9				[2023]
Chlorine dioxide	[10049-04-4]	0.1	0.28						
2-Chloro-1,3-butadiene (β-Chloroprene)	[126-99-8]	10	36					skin	
1-Chloro-2,3-epoxy propane (Epichlorohydrin)	[106-89-8]	0.05	0.19	0.15	0.58			carcinogen category 1; skin; dsen	2019
Chloroacetaldehyde	[107-20-0]					1	3.2		

C		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Chloroacetone	[78-95-5]					1	3.8	skin	
Chloroacetophenone (Phenacyl chloride)	[532-27-4]	0.05	0.32						
Chloroacetyl chloride	[79-04-9]	0.05	0.23	0.15	0.69			skin	
Chlorobenzene (Monochlorobenzene)	[108-90-7]	10	46						[2023]
o-Chlorobenzylidene malononitrile	[2698-41-1]					0.05	0.39	skin	
Chlorobromomethane (Bromochloromethane)	[74-97-5]	200	1060						
Chlorodifluoromethane	[75-45-6]	1000	3540						[2023]
2-Chloroethanol (Ethylene chlorohydrin)	[107-07-3]					1	3.3	skin	[2023]
Chloroethylene (Vinyl chloride)	[75-01-4]	1	2.6					carcinogen category 1; dsen	2017
Chloroform (Trichloromethane)	[67-66-3]	0.5	2.5					carcinogen category 2; skin	2023
bis(Chloromethyl) ether	[542-88-1]	0.001	0.0047					carcinogen category 1	
Chloropentafluoroethane	[76-15-3]	1000	6320						
Chloropicrin (Nitrochloromethane, Trichloronitromethane)	[76-06-2]	0.1	0.67					dsen; rsen	
β-Chloroprene (2-Chloro-1,3-butadiene)	[126-99-8]	10	36					skin	
2-Chloropropionic acid	[598-78-7]	0.1	0.44					skin	
o-Chlorostyrene	[2039-87-4]	50	283	75	425				

C		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Chlorosulphonic acid	[7790-94-5]		1						
o-Chlorotoluene	[95-49-8]	50	259						
Chlorpyrifos	[2921-88-2]		0.2					skin; bio	
Chromite ore processing (Chromate), as Cr			0.05					carcinogen category 1	
Chromium (II) compounds, as Cr			0.5						
Chromium (III) compounds, as Cr	[16065-83-1]		0.5						
Chromium (VI) compounds, as Cr	[18540-29-9]		0.00002		0.0005			carcinogen category 1; bio; rsen; dsen for all chromium (VI) compounds except barium, lead and poorly soluble zinc chromates; skin for all water-soluble (≥500g/L) chromium VI compounds; ifv notation for chromyl chloride only, as it is a volatile liquid at room temperature	2020
Lead chromate	[7758-97-6]								
Strontium chromate	[7789-06-2]								
Calcium chromate	[13765-19-0]								
Chromyl chloride	[14977-61-8]								
Zinc chromate	[1350-65-9]								
Zinc potassium chromate	[1103-86-9]								
P.I. pigment yellow	[37300-23-5]								
Chromium metal	[7440-47-3]		0.5					rsen	
Chromyl chloride (see Chromium (VI) compounds, as Cr)	[14977-61-8]								
Chromyl chloride (see Chromium (VI) compounds, as Cr	[14977-61-8]							dsen	[2022]
Chrysotile (see Asbestos)									
Coal dust			3(r)						

C		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Coal tar pitch volatiles, as benzene solubles (PPAH, Particulate polycyclic aromatic hydrocarbons)	[65996-93-2]		0.2					carcinogen category 1	
Cobalt carbonyl, as Co	[10210-68-1]		0.02					dsen	
Cobalt metal dust and fume, as Co	[7440-48-4]		0.02					carcinogen category 2; bio; skin; dsen; rsen; oto	2018
Copper and its inorganic compounds, as Cu	[7440-50-8]		0.01(r)					dsen	2020
Cotton dust, raw			0.2						
Cresol, all isomers	[1319-77-3]	1	4.5					skin; ifv	2023
Cristobalite (see Silica-Crystalline)									
Crocidolite (see Asbestos)									
Crotonaldehyde	[4170-30-3]	2	5.7					carcinogen category 2; skin	
Cumene	[98-82-8]	25	125	75	375			skin	[2023]
Cyanamide	[420-04-2]		0.2					dsen; skin; ifv	2022
Cyanides									
Sodium cyanide	[143-33-9]		5					skin; dsen	2020
Potassium cyanide	[151-50-8]								
Cyanogen chloride	[506-77-4]					0.3	0.75		
Cyclohexane	[110-82-7]	100	350	300	1050				
Cyclohexanol	[108-93-0]	50	206					skin	
Cyclohexanone	[108-94-1]	25	100					skin	[2023]
Cyclohexene	[110-83-8]	300	1010						

C		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Cyclohexylamine	[108-91-8]	2	8.2			5	20.5		2023
Cyclopentadiene	[542-92-7]	75	203						
Cyclopentane	[287-92-3]	600	1720						

D		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
2,4-D (including its salts and esters)	[94-75-7]		10					dsen; skin	2023
Di(2-ethylhexyl)phthalate (Di-sec-octyl phthalate)	[117-81-7]		2		4			skin	[2022]
Diacetone alcohol (4-Hydroxy-4- methyl-2-pentanone)	[123-42-2]	50	238						[2023]
Diallyl phthalate	[131-17-9]		5						
1,2-Diaminoethane (Ethylenediamine)	[107-15-3]	10	25					skin; dsen; rsen	
Diatomaceous earth (not calcined) (see Silica-Amorphous)	[61790-53-2]		10						
Diazinon	[333-41-5]		0.1					skin; bio	
Diborane	[19287-45-7]	0.1	0.11						
1,2-Dibromoethane (Ethylene dibromide)	[106-93-4]	0.0003	0.002					carcinogen category 1; skin	2019
Dibutyl phenyl phosphate	[2528-36-1]	0.3	3.5					skin; bio	

D		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Dibutyl phthalate	[84-74-2]	0.05	0.58						2022
2-N-Dibutylaminoethanol	[102-81-8]	2	14					skin; bio	
1,1-Dichloro-1-nitroethane	[594-72-9]	2	12						
1,3-Dichloro-5,5-dimethyl hydantoin	[118-52-5]		0.2		0.4				
Dichloroacetylene	[7572-29-4]					0.1	0.39	carcinogen category 2	
o-Dichlorobenzene	[95-50-1]	10	61	20	122				[2021]
p-Dichlorobenzene	[106-46-7]	2	12	10	60			carcinogen category 2; skin	2019
Dichlorodifluoromethane	[75-71-8]	1000	4950						
1,2-Dichloroethane (Ethylene dichloride)	[107-06-2]	5	21					skin; dsen	
1,1-Dichloroethane (Ethylidene chloride)	[75-34-3]	100	405	250	1010				2022
Dichloroethyl ether	[111-44-4]	5	29	10	58			skin	
1,2-Dichloroethylene (Acetylene dichloride)	[540-59-0]	200	793						
1,1-Dichloroethylene (Vinylidene chloride)	[75-35-4]	2	8	5	20				2023
Dichlorofluoromethane	[75-43-4]	10	42						
Dichloromethane (Methylene chloride)	[75-09-2]	50	174					carcinogen category 2	
1,2-Dichloropropane (Propylene dichloride)	[78-87-5]	5	23					confirmed carcinogen	2019
Dichloropropene	[542-75-6]	1	4.5					skin; dsen	
2,2-Dichloropropionic acid	[75-99-0]	1	5.8						

D		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Dichlorotetrafluoroethane	[76-14-2]	1000	6990						
Dichlorvos	[62-73-7]	0.1	0.9					carcinogen category 2; skin; dsen; bio	2019
Dicyclohexyl phthalate	[84-61-7]		5						
Dicyclopentadiene	[77-73-6]	0.5	2.7	1	5.4				2023
Dicyclopentadienyl iron	[102-54-5]		5						
Diesel fuel			100					skin; [Diesel fuel (liquid and vapour) is not to be confused with diesel particulate matter. If the polycyclic aromatic hydrocarbon content of the diesel fuel is greater than 5%, it is recommended that PAH exposures are also assessed.]	2022
Diesel Particulate Matter (DPM) as elemental carbon			0.1					[Diesel engine exhaust is a confirmed carcinogen]	2016
Diethanolamine	[111-42-2]	3	13					skin	
Diethyl ether (Ethyl ether)	[60-29-7]	400	1210	500	1520				[2023]
Diethyl ketone	[96-22-0]	200	705						
Diethyl phthalate	[84-66-2]		5						
Diethyl sulphate	[64-67-5]	0.01	0.06					carcinogen category 1; skin; †	2020
Diethylamine	[109-89-7]	2	6	5	15			skin	2022
2-Diethylaminoethanol	[100-37-8]	10	48					skin	[2023]
Diethylene glycol	[111-46-6]	10	44	40	176			ifv	2022
Diethylene triamine	[111-40-0]	1	4.2					skin; dsen; rsen	
Difluorodibromomethane	[75-61-6]	100	858						
Dihydroxybenzene (Hydroquinone)	[123-31-9]		1					skin; dsen	2020

D		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Diisobutyl ketone (2,6-Dimethyl-4-heptanone)	[108-83-8]	25	145						
Diisobutyl phthalate	[84-69-5]		5						
Diisooctyl phthalate	[27554-26-3]		5						
Diisodecyl phthalate	[26761-40-0]		5						
Diisononyl phthalate	[28553-12-0]		5						
Diisopropylamine	[108-18-9]	5	21					skin	
Dimethoxymethane (Methylal)	[109-87-5]	1000	3110						[2023]
Dimethyl acetamide	[127-19-5]	5	18					skin	2023
Dimethyl sulphate	[77-78-1]	0.01	0.05					carcinogen category 1; skin; dsen	2019
Dimethyl-1,2-dibromo-2, 2-dichloroethyl phosphate (Naled)	[300-76-5]		3					skin	
2,6-Dimethyl-4-heptanone (Diisobutyl ketone)	[108-83-8]	25	145						
Dimethylamine	[124-40-3]	2	3.8						2022
Dimethylaminobenzene (Xylidine, mixed isomers)	[1300-73-8]	0.5	2.5					carcinogen category 2; skin	
Dimethylaminoethanol	[108-01-0]	2	7.4	6	22				
N,N-Dimethylaniline	[121-69-7]	5	25	10	50			skin	
Dimethylbenzene (see Xylene)		50	217						
Dimethylether	[115-10-6]	400	766	500	958				
N,N-Dimethylethylamine	[598-56-1]	2	6.1			5	15		2023

D		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Dimethylformamide	[68-12-2]	5	15					skin	2022
1,1-Dimethylhydrazine	[57-14-7]	0.01	0.025					carcinogen category 2; skin	
Dimethylphthalate	[131-11-3]		5						
Dinitolmide (3,5-Dinitro-o-toluamide)	[148-01-6]		1						2022
Dinitrobenzene, all isomers	[528-29-0] [99-65-0] [100-25-4]	0.15	1					skin	
Dinitro-o-cresol	[534-52-1]							Revoked	2020
3,5-Dinitro-o-toluamide (Dinitolmide)	[148-01-6]		1						2022
Dinonyl phthalate	[84-76-4]		5						
Dioxane	[123-91-1]	5	18					carcinogen category 1; skin	2020
Diphenyl (Biphenyl)	[92-52-4]	0.2	1.3						
Diphenylamine	[122-39-4]		10						[2023]
Dipropyl ketone	[123-19-3]	50	233						
Dipropylene glycol methyl ether	[34590-94-8]	100	606	150	909			skin	[2023]
Diquat cation (regardless of source) Diquat Diquat dibromide	[2764-72-9]		0.5; 0.1(r)					skin; dsen	2022
Di-sec-octyl phthalate (Di(2-ethylhexyl)phthalate)	[117-81-7]		2		4			skin	2023
Disulfiram	[97-77-8]		2					dsen	

D		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
2,6-Di-tert-butyl-p-cresol (Butylated hydroxytoluene)	[128-37-0]		10						
Diuron	[330-54-1]		10					carcinogen category 2	
Divinyl benzene	[1321-74-0]	10	53						

E		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Emery	[1302-74-5]		10						
Enzymes (see Subtilisins)									
Epichlorohydrin (1-Chloro-2,3-epoxy propane)	[106-89-8]	0.05	0.19	0.15	0.58			carcinogen category 1; skin; dsen	2019
2,3-Epoxy-1-propanol (Glycidol)	[556-52-5]	2	6					carcinogen category 1; skin	2019
1,2-Epoxypropane (Propylene oxide)	[75-56-9]	2	4.8					carcinogen category 2; dsen	2018
Ethane	[74-84-0]							sax	
Ethanedinitrile (EDN)	[460-19-5]	3	6.4			5	10.6	PES; oto	2018
Ethanethiol (Ethyl mercaptan)	[75-08-1]	0.5	1.3						
Ethanol (Ethyl alcohol)	[64-17-5]	200	380	800	1520			oto	2023
Ethanolamine (2-Aminoethanol)	[141-43-5]	0.2	0.5	0.2	0.5				2023
2-Ethoxyethanol (Glycol monoethyl ester)	[110-80-5]	2	8					skin; bio	2022
2-Ethoxyethyl acetate (EGEEA)	[111-15-9]	2	11					skin; bio	2022

E		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Ethyl acetate	[141-78-6]	200	720						
Ethyl acrylate	[140-88-5]	2	8.3	4	16.6			dsen; skin	2023
Ethyl alcohol (Ethanol)	[64-17-5]	200	380	800	1520			oto	2023
Ethyl amyl ketone (5-Methyl-3-heptanone)	[541-85-5]	25	131						[2023]
Ethyl benzene	[100-41-4]	20	88	40	176			skin; oto	2022
Ethyl bromide	[74-96-4]	5	22					carcinogen category 2; skin	
Ethyl butyl ketone (3-Heptanone)	[106-35-4]	10	47	20	93				2023
Ethyl chloride	[75-00-3]	100	264					carcinogen category 2; dsen	2019
Ethyl ether (Diethyl ether)	[60-29-7]	400	1210	500	1520				[2023]
Ethyl formate	[109-94-4]	100	303						
Ethyl mercaptan (Ethanethiol)	[75-08-1]	0.5	1.3						
Ethyl silicate	[78-10-4]	10	85						[2023]
Ethylamine	[75-04-7]	10	18					skin	[2023]
Ethylene	[74-85-1]							sa	
Ethylene chlorohydrin (2-Chloroethanol)	[107-07-3]					1	3.3	skin	[2023]
Ethylene dibromide (1,2-Dibromoethane)	[106-93-4]	0.0003	0.002					carcinogen category 1; skin	2019
Ethylene dichloride (1,2-Dichloroethane)	[107-06-2]	5	21					skin; dsen	

E		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Ethylene glycol (vapour and mist)	[107-21-1]					50	127		[2023]
Ethylene glycol dinitrate	[628-96-6]			0.01	0.063			skin	2023
Ethylene glycol isopropyl ether	[109-59-1]	25	106						[2023]
Ethylene glycol methyl ether acetate (2-Methoxyethyl acetate)	[110-49-6]	0.1	0.5					skin	2019
Ethylene oxide	[75-21-8]	0.1	0.2					carcinogen category 1; skin; dsen; rsen	2019
Ethylenediamine (1,2-Diaminoethane)	[107-15-3]	10	25					skin; dsen; rsen	
Ethyleneimine	[151-56-4]	0.5	0.88					carcinogen category 2; skin	
Ethylidene chloride (1,1-Dichloroethane)	[75-34-3]	200	810	250	1010				[2021]
Ethylidene norbornene	[16219-75-3]					5	25		
N-Ethylmorpholine	[100-74-3]	5	24					skin	

F		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Ferrovanadium dust	[12604-58-9]		1						
Fibrous glass dust (see Synthetic mineral fibres)									
Flour dust			1					rsen; †	2018
Fluorides, as F			2.5					bio	[2023]
Fluorine	[7782-41-4]	0.1	0.16			0.5	0.78		2023

F		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Fluorotrichloromethane (Trichlorofluoromethane)	[75-69-4]					1000	5620		[2023]
Formaldehyde	[50-00-0]	0.3		0.6				carcinogen category 1; dsen;	2022
Formamide	[75-12-7]	10	18					skin	
Formic acid	[64-18-6]	5	9.4	10	19				
Furfural	[98-01-1]	0.2	0.8					carcinogen category 2; skin	2019
Furfuryl alcohol	[98-00-0]	10	40	15	60			skin	

G		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Gasoline (Petrol)	[8006-61-9]	300	890	500	1480				
Glass, fibrous or dust (see Synthetic mineral fibres)									
Glutaraldehyde	[111-30-8]					0.05	0.21	dsen; rsen	2019
Glycerin (mist)	[56-81-5]		10						
Glycidol (2,3-Epoxy-1-propanol)	[556-52-5]	2	6					carcinogen category 1; skin	2019
Glycol monoethyl ether (2-Ethoxyethanol)	[110-80-5]	2	8					skin; bio	2022
Grain dust (oat, wheat, barley)			4						
Graphite, all forms except graphite fibres	[7782-42-5]		3(r)						
Gypsum (Calcium sulphate)	[7778-18-9]		10						

H		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
Halothane	[151-67-7]	0.5						rsen	
Helium	[7440-59-7]							sa	
Heptane (n-Heptane)	[142-82-5]	400	1640	500	2050			oto	
3-Heptanone (Ethyl butyl ketone)	[106-35-4]	50	234						[2022]
2-Heptanone (Methyl n-amyl ketone)	[110-43-0]	50	233						
Hexachlorocyclopentadiene	[77-47-4]	0.01	0.11						
Hexachloroethane	[67-72-1]	1	9.7					carcinogen category 2; skin	
Hexafluoroacetone	[684-16-2]	0.1	0.68					skin	
Hexane (n-Hexane)	[110-54-3]	20	72					bio; oto	[2023]
Hexane, Other isomers	[110-54-3]	500	1760	1000	3500				[2023]
2-Hexanone (Methyl n-butyl ketone)	[591-78-6]	5	20					skin	
Hexone (Methyl isobutyl ketone)	[108-10-1]	50	205	75	307				[2023]
sec-Hexyl acetate	[108-84-9]	50	295						
Hexylene glycol	[107-41-5]					25	121		[2023]
Hydrazine	[302-01-2]	0.0002	0.00026					carcinogen category 2; skin; dsen	2019
Hydrogen	[1333-74-0]							sax	
Hydrogen bromide	[10035-10-6]					3	9.9		[2023]
Hydrogen chloride	[7647-01-0]					5	7.5		[2023]

H		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Hydrogen cyanide	[74-90-8]	1	1			5	5	skin; oto; [The level of skin absorption for gaseous hydrogen cyanide is acknowledged to be low compared with its salts and aqueous solutions]	2022
Hydrogen fluoride, as F	[7664-39-3]					3	2.6	bio	[2023]
Hydrogen peroxide	[7722-84-1]	1	1.4						[2023]
Hydrogen sulphide	[7783-06-4]	5	7	10	14			†	2019
Hydrogenated terphenyls	[61788-32-7]	0.5	4.9						
Hydroquinone (Dihydroxybenzene)	[123-31-9]		1					skin; dsen	2020
4-Hydroxy-4-methyl-2-pentanone (Diacetone alcohol)	[123-42-2]	50	238						[2023]
2-Hydroxypropyl acrylate	[999-61-1]	0.5	2.8					skin	

I		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Indium and compounds, as In	[7440-74-6]		0.1						
Inhalable dust (not otherwise classified)			10						
Iodine	[7553-56-2]	0.01	0.05			0.1	1		2022
Iodoform	[75-47-8]	0.6	10						
Iodomethane	[74-88-4]	2	12					skin	
Iron oxide dust and fume (Fe2O3), as Fe	[1309-37-1]		5					w	

		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
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]	5	18	10	37				2023
Isobutyl acetate	[110-19-0]	150	713						[2023]
Isobutyl alcohol	[78-83-1]	50	152						
Isocyanates, all, (as –NCO)									
Hexamethylene diisocyanate	[822-06-0]								
Isophorone diisocyanate	[4098-71-9]								
MDI Diphenylmethane diisocyanate Methylene bisphenyl isocyanate	[101-68-8]		0.02		0.07			dsen; rsen; skin; ifv; † [skin notation applies to isophorone diisocyanate only; WES values apply to all isocyanates, including prepolymers, present in the workplace air as vapours, mist or dust]	2022
Methylene bis(4-cyclohexylisocyanate)	[5124-30-1]								
TDI									
Toluene-2,4-diisocyanate	[584-84-9]								
Toluene-2,6-diisocyanate	[91-08-7]								
Isooctyl alcohol	[26952-21-6]	50	266					skin	
Isophorone	[78-59-1]					5	28	carcinogen category 2	[2023]
Isopropyl acetate	[108-21-4]	250	1040	310	1290				
Isopropyl alcohol	[67-63-0]	400	983	500	1230				[2023]
Isopropyl ether	[108-20-3]	250	1040	310	1300				[2023]
Isopropyl glycidyl ether (IGE)	[4016-14-2]	50	238	75	356				
Isopropylamine	[75-31-0]	5	12	10	24				

K		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Kaolin	[1332-58-7]		10 2(r)						
Ketene	[463-51-4]	0.5	0.86						

L		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Lead chromate, as Cr	[7758-97-6]							see Chromium (VI) compounds, as Cr	2020
Lead, inorganic dusts and fumes, as Pb	[7439-92-1]		0.05					carcinogen category 2; bio; oto	2019
Limestone (Calcium carbonate)	[1317-65-3]		10						
Lindane	[58-89-9]		0.1					carcinogen category 2; skin	
Lithium hydride	[7580-67-8]		0.025						
Lithium hydroxide	[1310-65-2]				1				
LPG (Liquefied petroleum gas)	[68476-85-7]	1000	1800						

M		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Magnesite	[546-93-0]		10						
Magnesium oxide fume	[1309-48-4]		10						[2023]
Malathion	[121-75-5]		1					skin; ifv; dsen; bio	2019
Maleic anhydride	[108-31-6]	0.0025	0.01					sen; ifv	2019

M		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Manganese cyclopentadienyl tricarbonyl, as Mn	[12079-65-1]		0.1					skin	
Manganese fume, dust and compounds, as Mn	[7439-96-5]		0.2 0.02(r)					oto	2018
Man-made mineral fibres (see Synthetic mineral fibres)									
Marble (Calcium carbonate)	[471-34-1]		10						
MEK (Methyl ethyl ketone, 2-Butanone)	[78-93-3]	150	445	300	890			bio	
Mercury vapour (as Hg)	[7439-97-6]		0.025					skin; bio; dsen; oto	2022
Mercury, Alkyl compounds (as Hg)			0.01					skin; oto	2022
Mercury, Inorganic compounds (as Hg)			0.025					skin; oto	2022
Mesityl oxide	[141-79-7]	2	8.1	25	100			skin	2023
Methacrylic acid	[79-41-4]	20	70						
Methane	[74-82-8]							sax	
Methanethiol (Methyl mercaptan)	[74-93-1]	0.5	0.98						
Methanol (Methyl alcohol)	[67-56-1]	200	262	250	328			skin; bio	2023
Methomyl	[16752-77-5]		2.5					bio	
Methoxychlor	[72-43-5]		10						
2-Methoxyethanol	[109-86-4]	0.1	0.3					skin	2019
2-Methoxyethyl acetate (Ethylene glycol methyl ether acetate)	[110-49-6]	0.1	0.5					skin	2019
4-Methoxyphenol	[150-76-5]		5					dsen	

M		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Methyl 2-cyanoacrylate	[137-05-3]	2	9.1	4	18				
Methyl acetate	[79-20-9]	200	606	250	757				[2023]
Methyl acetylene (Propyne)	[74-99-7]	1000	1640						
Methyl acetylene-propadiene mixture (MAPP)	[59355-75-8]	1000	1640	1250	2050				
Methyl acrylate	[96-33-3]	2	7.1	4	14.2			skin; dsen	2022
Methyl alcohol (Methanol)	[67-56-1]	200	262	250	328			skin; bio	2023
Methyl amyl alcohol (Methyl isobutyl carbinol)	[108-11-2]	25	104	40	167			skin	[2023]
N-Methyl aniline	[100-61-8]	0.5	2.2					skin	[2023]
Methyl bromide	[74-83-9]	1	3.9	2	7.8			skin	2022
Methyl chloride	[74-87-3]	20	42	100	207			skin	2023
Methyl chloroform (1,1,1-Trichloroethane)	[71-55-6]	100	555	200	1110			skin	2022
Methyl ethyl ketone (MEK, 2-Butanone)	[78-93-3]	150	445	300	890			bio	
Methyl ethyl ketone peroxide	[1338-23-4]					0.2	1.5		
Methyl formate	[107-31-3]	100	246	150	368				[2022]
Methyl iodide	[74-88-4]	2	12					carcinogen category 2; skin	
Methyl isoamyl ketone	[110-12-3]	20	93	50	233				2023
Methyl isobutyl carbinol (Methyl amyl alcohol)	[108-11-2]	25	104	40	167			skin	[2023]
Methyl isobutyl ketone (Hexone)	[108-10-1]	50	205	75	307				[2023]

M		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Methyl isopropyl ketone	[563-80-4]	200	705						
Methyl mercaptan (Methanethiol)	[74-93-1]	0.5	0.98						
Methyl methacrylate	[80-62-6]	50	208	100	416			skin; dsen	[2023]
Methyl n-amyl ketone (2-Heptanone)	[110-43-0]	50	233						
Methyl n-butyl ketone (2-Hexanone)	[591-78-6]	5	20					skin	
Methyl propyl ketone (2-Pentanone)	[107-87-9]	200	705	250	881				
Methyl silicate	[681-84-5]	1	6						
α-Methyl styrene	[98-83-9]	50	242	100	483			oto	
1-Methyl-2-pyrrolidone	[872-50-4]	10	40	20	80			skin	2023
5-Methyl-3-heptanone (Ethyl amyl ketone)	[541-85-5]	25	131						[2023]
Methylacrylonitrile	[126-98-7]	1	2.7					skin; dsen	
Methylal (Dimethoxymethane)	[109-87-5]	1000	3110						[2023]
Methylamine	[74-89-5]	5	6.4	10	13				2022
Methylcyclohexane	[108-87-2]	400	1610						[2023]
Methylcyclohexanol	[25639-42-3]	50	234						
o-Methylcyclohexanone	[583-60-8]	50	229	75	344			skin	
2-Methylcyclopentadienyl manganese tricarbonyl, as Mn	[12108-13-3]		0.2					skin	
4,4-Methylene bis(2-chloroaniline) (MOCA)	[101-14-4]		0.005					carcinogen category 1; skin	

M		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Methylene chloride (Dichloromethane)	[75-09-2]	50	174					carcinogen category 2	
4,4-Methylene dianiline	[101-77-9]	0.002	0.016					carcinogen category 2; skin; dsen	2019
Methyl-tert butyl ether	[1634-04-4]	25	92	75	275				
Metribuzin	[21087-64-9]		5						
Mica	[12001-26-2]		3(r)						
Mineral wool fibre (see Synthetic mineral fibres)									
MOCA (4,4-Methylene bis(2-chloroaniline))	[101-14-4]		0.005					carcinogen category 1; skin	
Molybdenum, as Mo Soluble compounds Insoluble compounds	[7439-98-7]		5 10						
Monochloroacetic acid	[79-11-8]	0.3	1.2					skin	
Monochlorobenzene (Chlorobenzene)	[108-90-7]	10	46						[2023]
Morpholine	[110-91-8]	20	71					skin	[2023]

N		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Naled (Dimethyl-1,2-dibromo-2,2- dichloroethyl phosphate)	[300-76-5]		3					skin; bio	
Naphthalene	[91-20-3]	0.5	2.6	2	10			carcinogen category 2; skin	2019
Neon	[7440-01-9]							sa	

N		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Nickel, elemental or metallic	[7440-02-0]		0.005(r)					carcinogen category 2; sen	2018
Nickel, inorganic compounds			0.02 0.005(r)					carcinogen category 2; sen	2018
Nicotine	[54-11-5]		0.5					skin	
Nitric acid	[7697-37-2]	2	5.2	4	10				[2023]
Nitric oxide	[10102-43-9]	2	2.5						2023
p-Nitroaniline	[100-01-6]		3					skin	
Nitrobenzene	[98-95-3]	0.1	0.5					carcinogen category 2; skin	2022
p-Nitrochlorobenzene	[100-00-5]	0.1	0.64					carcinogen category 2; skin	
Nitrochloromethane (Chloropicrin, Trichloronitromethane)	[76-06-2]	0.1	0.67						
Nitroethane	[79-24-3]	10	31	40	124			skin	2023
Nitrogen	[7727-37-9]							sa	
Nitrogen dioxide	[10102-44-0]	1	1.9					†	2020
Nitromethane	[75-52-5]	20	50					carcinogen category 2	
1-Nitropropane	[108-03-2]	2	7.4	16	58.2			skin	2023
2-Nitropropane	[79-46-9]	5	19					carcinogen category 2	
Nitrotoluene		2	11					skin	
o-Nitrotoluene	[88-72-2]								
m-Nitrotoluene	[99-08-1]								
p-Nitrotoluene	[99-99-0]								
Nitrous oxide	[10024-97-2]	25	45						
Nonane	[111-84-2]	200	1050						

O		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Octane	[111-65-9]	300	1400	375	1750				
Oil mist, mineral	[8012-95-1]		5		10			om	
Osmium tetroxide, as Os	[20816-12-0]	0.0002	0.0016						
Oxalic acid	[144-62-7]		1		2				
Ozone	[10028-15-6]					0.1	0.2		

P		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Paraffin wax fume	[8002-74-2]		2						
Paraquat	[4685-14-7]		0.1(r)						
Particulate polycyclic aromatic hydrocarbons (PPAH, Coal tar pitch volatiles)	[65996-93-2]		0.2					carcinogen category 1	
PCBs (Polychlorinated Biphenyls)	[1336-36-3]		0.1					p	
Pentachloronaphthalene	[1321-64-8]		0.5						
Pentachloronitrobenzene	[82-68-8]		0.5						
Pentachlorophenol	[87-86-5]		0.5					carcinogen category 2; skin	
Pentaerythritol	[115-77-5]		10						
Pentane	[109-66-0]	600	1770	750	2210				
2-Pentanone (Methyl propyl ketone)	[107-87-9]	200	705	250	881				
Perchloroethylene (Tetrachloroethylene)	[127-18-4]	20	136	40	271			carcinogen category 1; skin	2018

P		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Perchloromethyl mercaptan	[594-42-3]	0.1	0.76						
Perlite	[93763-70-3]		10						
Petrol (Gasoline)	[8006-61-9]	300	890	500	1480				
Phenacyl chloride (2-Chloroacetophenone)	[532-27-4]	0.05	0.32						
Phenol	[108-95-2]	1	3.8	2	7.7			skin	2020
Phenothiazine	[92-84-2]		5						
Phenyl ether vapour	[101-84-8]	1	7	2	14				
Phenyl glycidyl ether (PGE)	[122-60-1]	0.1	0.6					carcinogen category 2; skin; dsen	2019
Phenyl mercaptan	[108-98-5]	0.5	2.3						
m-Phenylenediamine	[108-45-2]		0.1					dsen	
o-Phenylenediamine	[95-54-5]		0.1					carcinogen category 2; dsen	
p-Phenylenediamine	[106-50-3]		0.1					skin; dsen	
Phenylethylene (Styrene monomer, vinyl benzene)	[100-42-5]	20	85	40	170			carcinogen category 2; oto	2018
Phenylhydrazine	[100-63-0]	0.1	0.44					carcinogen category 2; skin; dsen	
Phenylphosphine	[638-21-1]					0.05	0.23		
Phorate	[298-02-2]		0.05		0.2			skin; bio	
Phosgene (Carbonyl chloride)	[75-44-5]	0.02	0.08	0.06	0.25				
Phosphine	[7803-51-2]	0.3	0.42	1	1.4			†	2023
Phosphoric acid	[7664-38-2]		1						
Phosphorous (yellow)	[7723-14-0]		0.1						

P		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Phosphorous oxychloride	[10025-87-3]	0.01	0.064	0.02	0.12				2023
Phosphorous pentachloride	[10026-13-8]	0.1	0.85						
Phosphorous pentasulphide	[1314-80-3]		1						
Phosphorous trichloride	[7719-12-2]	0.2	1.1	0.5	2.8				[2023]
Phthalic anhydride	[85-44-9]	0.002	0.01					skin; dsen; rsen	2019
m-Phthalodinitrile	[626-17-5]		5						
Picloram	[1918-02-1]		10						
Picric acid (2,4,6-Trinitrophenol)	[88-89-1]		0.1		0.2			dsen; skin	2022
Pindone (2-Pivaloyl-1,3-indandione)	[83-26-1]		0.1						
Piperazine dihydrochloride	[142-64-3]		5						
Piperidine	[110-89-4]	1	3.5					skin	
2-Pivaloyl-1,3-indandione (Pindone)	[83-26-1]		0.1						
Plaster of Paris (Calcium sulphate)	[7778-18-9]		10						
Platinum metal	[7440-06-4]		1						
Platinum, Soluble salts, as Pt			0.002					dsen	
Polychlorinated Biphenyls (PCBs)	[1336-36-3]		0.1					p	
Portland cement	[65997-15-1]		3 1(r)					dsen	2018
Potassium hydroxide	[1310-58-3]						2		

P		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
PPAH (Particulate polycyclic aromatic hydrocarbons, Coal tar pitch volatiles)	[65996-93-2]		0.2					carcinogen category 1	
Precipitated silica (Silica-Amorphous)			10						
Propane	[74-98-6]							sax	
Propane-1,2-diol, Particulates only	[57-55-6]		10						
Propane-1,2-diol, Vapour and particulates	[57-55-6]	150	474						
Propargyl alcohol	[107-19-7]	1	2.3					skin; dsen	
β-Propiolactone	[57-57-8]	0.5	1.5					carcinogen category 2	
Propionic acid	[79-09-4]	10	30						
Propoxur	[114-26-1]		0.5					carcinogen category 2; bio	
Propranolol	[525-66-6]		2		6				
n-Propyl acetate	[109-60-4]	200	835	250	1040				
n-Propyl alcohol	[71-23-8]	200	492	250	614			skin	
n-Propyl nitrate	[627-13-4]	25	107	40	172				
Propylene	[115-07-1]							sax	
Propylene dichloride (1,2-Dichloropropane)	[78-87-5]	5	23					confirmed carcinogen	2019
Propylene glycol dinitrate	[6423-43-4]			0.01	0.069			skin	2023
Propylene glycol monomethyl ether	[107-98-2]	100	369	150	553				
Propylene oxide (1,2-Epoxypropane)	[75-56-9]	2	4.8					carcinogen category 2; dsen	2018

P		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Propyne (Methyl acetylene)	[74-99-7]	1000	1640						
Pyrethrum	[8003-34-7]		5					dsen	
Pyridine	[110-86-1]	1	3.2					carcinogen category 2; skin	2019
Pyrocatechol (Catechol)	[120-80-9]	5	23					skin	

Q		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Quartz (see Silica-Crystalline)									
Quinone (p-Benzoquinone)	[106-51-4]	0.1	0.44						

R		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
RDX (Cyclonite)	[121-82-4]		1.5					skin	
Resorcinol	[108-46-3]	10	45	20	90				
Respirable dust (not otherwise classified)			3(r)						
Rhodium metal	[7440-16-6]		1						
Rhodium, Insoluble compounds, as Rh			1						
Rhodium, Soluble compounds, as Rh			0.01						

R		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Rosin core solder thermal decomposition products as resin acids (colophony)								dsen; rsen [Reduce to the lowest practicable level]	
Rotenone (commercial)	[83-79-4]		5						
Rouge			10					w	
Rubber fume (as cyclohexane soluble material)			0.6						
Rubber process dust			6						
Rubber solvent (Naphtha)		400	1600						

S		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Selenium and compounds, as Se	[7782-49-2]		0.02					skin	2023
Silane (Silicon tetrahydride)	[7803-62-5]	5	6.6						
Silica fume	[69012-64-2]		2(r)						
Silica fused	[60676-86-0]		0.2(r)						
Silica-Amorphous, Diatomaceous earth (not calcined)	[61790-53-2]		10						
Silica-Amorphous, Precipitated silica	[112926-00-8]		10						
Silica-Amorphous, Silica gel	[63231-67-4]		10						

S		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Silica-Crystalline (all forms)			0.025(r)					carcinogen category 1; α-quartz and cristobalite are confirmed carcinogens. Significant risk to workers will remain at WES-TWA exposures of 0.025mg/m³. The US Occupational Safety and Health Administration (OSHA) has estimated the lifetime silicosis mortality risk for workers exposed at this level for 8 hours per day at between 4 and 22 deaths per 1,000 workers and the lifetime lung cancer mortality risk for workers exposed at this level for 8 hours per day at between 3 and 23 deaths per 1,000 workers.	2023
Silicon	[7440-21-3]		10						
Silicon carbide	[409-21-2]		10						
Silicon tetrahydride (Silane)	[7803-62-5]	5	6.6						
Silver metal	[7440-22-4]		0.1						
Silver, Soluble compounds, as Ag			0.01						
Soapstone			6 3(r)						
Sodium azide	[26628-22-8]					0.11	0.29		[2023]
Sodium bisulphite	[7631-90-5]		5					dsen; rsen	
Sodium disulphite	[7681-57-4]		5					dsen; rsen	
Sodium fluoroacetate (1080)	[62-74-8]		0.05					skin; bio	
Sodium hydroxide	[1310-73-2]						2		
Starch	[9005-25-8]		10						
Stearates			10						
Stibine (Antimony hydride)	[7803-52-3]	0.1	0.51						

S		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
Stoddard solvent (White spirits)	[8052-41-3]	100	525						
Strontium chromate, as Cr	[7789-06-2]							see Chromium (VI) compounds, as Cr	2020
Strychnine	[57-24-9]		0.15						
Styrene monomer (Phenylethylene, vinyl benzene)	[100-42-5]	20	85	40	170			carcinogen category 2; oto	2018
Subtilisins (Proteolytic enzymes, as 100% pure crystalline enzyme)	[1395-21-7]; [9014-01-1]						0.00006	skin; rsen	
Sucrose	[57-50-1]		10						
Sulfotep (TEDP)	[3689-24-5]		0.2					skin; bio	
Sulphur dioxide	[7446-09-5]			0.25	0.66			rsen	2019
Sulphur hexafluoride	[2551-62-4]	1000	5970						
Sulphur monochloride	[10025-67-9]					1	5.5		
Sulphuric acid	[7664-93-9]		0.1					carcinogen category 1	2018
Sulphuryl fluoride	[2699-79-8]	5	21	10	42				
Synthetic mineral fibres (Man-made mineral fibres)			2mg/m³* 0.3f/ml**					[*for non-carcinogenic SMFs; ** for carcinogenic SMFs]	2020

T		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
2,4,5-T	[93-76-5]		10						
Talc (containing asbestos fibres)								[Use asbestos standards]	

T		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Talc (containing no asbestos fibres)	[14807-96-6]		2(r)						
Tantalum metal	[7440-25-7]		5						
Tantalum, Oxide dusts	[1314-61-0]		5						
TEDP (Sulfotep)	[3689-24-5]		0.2					skin	
Tellurium and compounds, as Te	[13494-80-9]		0.1						
Temephos	[3383-96-8]		10					bio	
Terephthalic acid	[100-21-0]		10						[2023]
Terphenyls	[26140-60-3]					0.5	4.7		
1,1,1,2-Tetrachloro-2,2-difluoroethane	[76-11-9]	500	4170						[2023]
1,1,2,2-Tetrachloroethane	[79-34-5]	1	6.9					carcinogen category 2; skin	
Tetrachloroethylene (Perchloroethylene)	[127-18-4]	20	136	40	271			carcinogen category 1; skin	2018
Tetrachloromethane (Carbon tetrachloride)	[56-23-5]	0.1	0.63					carcinogen category 2; skin	
Tetraethyl lead, as Pb	[78-00-2]		0.1					skin; bio	
1,1,1,2-Tetrafluoroethane (HCF 134a)	[811-97-2]	1000	4200						
Tetrahydrofuran	[109-99-9]	50	150	100	300			carcinogen category 2; skin	2022
Tetramethyl succinonitrile	[3333-52-6]	0.5	2.8					skin	
Tetrasodium pyrophosphate	[7722-88-5]		5						
Tetryl (2,4,6-Trinitrophenyl-methylnitramine)	[479-45-8]		1.5					sen	

T		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Thallium soluble compounds, as Tl	[7440-28-0]		0.02					skin	2023
4,4'-Thiobis(6-tert-butyl-m-cresol)	[96-69-5]		10						
Thioglycolic acid	[68-11-1]	1	3.8					skin	
Thionyl chloride	[7719-09-7]					1	4.9		
Thiram	[137-26-8]		0.2					ifv; dsen	2019
Tin Metal dusts, tin oxides and inorganic compounds (except SnH_4, and In_2O_5Sn) as Sn	[7440-31-5]		2						2023
Organic compounds including mono- and dimethyltin and n-butyltin (not otherwise classified) as Sn			0.05					skin; [some organic ligands may be sensitisers]	2023
non-irritant compounds					0.1				
irritant compounds					0.02				
Tri- and tetra-methyl tin compounds as Sn			0.005		0.02			skin; [some organic ligands may be sensitisers]; oto (trimethyltin)	2023
Titanium dioxide	[13463-67-7]		10					†	2023
TNT (2,4,6-Trinitrotoluene)	[118-96-7]		0.5					skin	
Toluene (Toluol)	[108-88-3]	20	75	100	377			skin; oto; bio	2022
m-Toluidine	[108-44-1]	2	8.8					skin	
o-Toluidine	[95-53-4]	0.2	0.89					carcinogen category 2; skin	
p-Toluidine	[106-49-0]	1	4.46	2	8.92			carcinogen category 2; skin; dsen	2023
Toluol (Toluene)	[108-88-3]	20	75	100	377			skin; oto; bio	2022
Tributyl phosphate	[126-73-8]	0.2	2.2					bio	

T		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
1,1,2-Trichloro-1,2,2-trifluoroethane	[76-13-1]	1000	7670	1250	9590				[2023]
Trichloroacetic acid	[76-03-9]			0.2	1.4			carcinogen category 2; ifv	2023
1,2,4-Trichlorobenzene	[120-82-1]					5	37		
1,1,1-Trichloroethane (Methyl chloroform)	[71-55-6]	100	555	200	1110			skin	2022
1,1,2-Trichloroethane	[79-00-5]	1	5.5	2	11			skin	2023
Trichloroethylene	[79-01-6]	10	55	25	135			carcinogen category 1; oto	2017
Trichlorofluoromethane (Fluorotrichloromethane)	[75-69-4]					1000	5620		[2023]
Trichloromethane (Chloroform)	[67-66-3]	2	9.9					carcinogen category 2; skin	[2022]
Trichloronaphthalene	[1321-65-9]		5					skin	
1,2,3-Trichloropropane	[96-18-4]	0.005	0.03					carcinogen category 2; skin	2017
Trichloronitromethane (Chloropicrin, Nitrochloromethane)	[76-06-2]	0.1	0.67						
Tridymite (see Silica-Crystalline)									
Triethanolamine	[102-71-6]		1						2023
Triethylamine	[121-44-8]	3	12	5	20			skin	[2023]
Trifluorobromomethane	[75-63-8]	1000	6090						
Triglycidyl isocyanurate (TGIC)	[2451-62-9]		0.08						
Trimellitic anhydride	[522-30-7]	0.005	0.039					dsen; rsen	
Trimethyl benzene	[25551-13-7]	25	123						

T		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Trimethyl phosphite	[121-45-9]	2	10					bio	
Trimethylamine	[75-50-3]	2	4.9			5	12		2023
2,4,6-Trinitrophenol (Picric acid)	[88-89-1]		0.1		0.2			dsen; skin	2022
2,4,6-Trinitrophenyl-methylnitramine (Tetryl)	[479-45-8]		1.5					sen	
2,4,6-Trinitrotoluene (TNT)	[118-96-7]		0.5					skin	
Triorthocresyl phosphate	[78-30-8]		0.02					skin; ifv; bio	2023
Triphenyl amine	[603-34-9]		5						
Triphenyl phosphate	[115-86-6]		3					bio	
Tripoli (see Silica-Crystalline)									
Tungsten, as W	[7440-33-7]								
Tungsten, as W, Insoluble compounds			5		10				
Tungsten, as W, Soluble compounds			1						
Turpentine and monoterpenes Turpentine α-Pinene β-Pinene δ-3-Carene Camphene	 [8006-64-2] [80-56-8] [127-91-3] [13466-78-9] [79-92-5]	5	28	10	56			dsen; skin	2022

U		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Uranium (natural) soluble and insoluble compounds, as U	[7440-61-1]		0.2					carcinogen category 1	

V		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
n-Valeraldehyde	[110-62-3]	50	176						
Vanadium, as V, and its inorganic compounds, except CI pigment yellow 184	[1314-62-1]		0.05					†	2020 [TBA]
Vegetable oil mists			10						
Vinyl acetate	[108-05-4]	5	18	10	35			carcinogen category 2; †	2020
Vinyl benzene (Styrene monomer, phenylethylene)	[100-42-5]	20	85	40	170			carcinogen category 2; oto	2018
Vinyl bromide	[593-60-2]	0.3	1.3					carcinogen category 1	2017
Vinyl chloride (Chloroethylene)	[75-01-4]	1	2.6					carcinogen category 1; dsen	2017
Vinyl cyanide (Acrylonitrile)	[107-13-1]	0.05	0.1					carcinogen category 1; skin; dsen; oto	2019
Vinyl cyclohexene dioxide	[106-87-6]	0.1	0.6					carcinogen category 2; skin	2019
Vinyl toluene	[25013-15-4]	20	98	40	196				2023
Vinylidene chloride (1,1-Dichloroethylene)	[75-35-4]	2	8	5	20				2023

W		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Warfarin	[81-81-2]		0.1						
Welding fume (not otherwise classified)								w; confirmed carcinogen [Evaluation of health risk in relation to welding should be based on known or expected components in welding fume, which would include various metal fumes as well as shielding gases and contaminants produced during combustion of surface coatings and cleaning products, where present. Many common fume constituents significantly contribute to health risk and have workplace exposure standards which can be used when assessing overall risk.]	2022
White spirits (Stoddard solvent)	[8052-41-3]	100	525						
Wood dust, hard			0.5					confirmed/suspected carcinogen depending on hard wood type; sen	2019
Wood dust, soft			2					†	2019 [2022]

X		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Xylene (o-, m-, p-isomers)	[1330-20-7] [95-47-6] [108-38-3] [106-42-3]	50	217					oto; bio	
m-Xylene a,a'-diamine	[1477-55-0]						0.1	skin	
Xylidine mixed isomers	[1300-73-8]	0.5	2.5					carcinogen category 2; skin	

Y		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Yttrium metal and compounds, as Y	[7440-65-5]		1						

Z		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Zinc chloride fume	[7646-85-7]		1		2				
Zinc chromates, as Cr	[13530-65-9] [11103-86-9] [37300-23-5]							see Chromium (VI) compounds, as Cr	2020
Zinc oxide	[1314-13-2]		2 0.1(r)		5 0.5(r)				2020
Zirconium and compounds, as Zr	[7440-67-7]		5		10				

TABLE 4: Workplace exposure standards

Part Two

BIOLOGICAL EXPOSURE INDICES

3.0 Biological exposure indices (BEI)

IN THIS SECTION:

3.1 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. BEI (Biological Exposure Indices) are guideline values for assessing biological monitoring results.

Biological exposure monitoring should not be confused with health monitoring. Exposure monitoring means the measurement and evaluation of exposure to a health hazard experienced by a person; and includes biological monitoring of the people.

Health monitoring, in relation to an individual, means monitoring of the individual to identify any changes in his or her health status because of exposure to certain health hazards. More information on health monitoring can be found in the good practice guidelines Exposure monitoring and health monitoring

Biological monitoring provides a better indication than does air monitoring of the bodily uptake of a chemical, as the monitored parameter is a reflection of not only the air level but also the breathing rate and depth, practice regarding respiratory protection, the absorption from other routes (such as skin and/or inadvertent hand to mouth ingestion), and the efficiency or otherwise of elimination. As such it reveals more about a specific individual's uptake of the chemical and hence their risk. It also reflects any additional non-workplace exposures to the chemical, which can add to risk. (The latter though can serve to complicate assessment of workplace exposure to the chemical.)

The monitoring result is compared to a standard established for the specific substance, termed its **biological exposure index (BEI)**. However there have been fewer BEIs than WESs set, as there is less data directly correlating adverse health effects to blood or urine levels than to air levels. Indeed most BEIs have been set indirectly from the chemical's WES.

Thus a BEI is considered by the ACGIH as a value often corresponding to the WES. That is, if a worker is exposed solely through inhalation, and that 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 (for example, blood or urine) levels as this knowledge enables extrapolation from a WES to a BEI. However, in some cases (such as with lead), the relationship between the biological level and the potential health effects has been approached more directly (for example, by identifying adverse effects as a function of blood lead levels, not air levels).

Other exceptions can be where a WES is set to protect against non-systemic effects such as tissue irritation or respiratory disorders, while a BEI is designed to avoid the risk of systemic effects.

3.2 Exposure periods

Depending on the toxicokinetics of the substance (for example its half life), 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 document 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.

3.3 Effectiveness

Biological monitoring has been widely used to monitor the uptake of cumulative toxins; for example lead, mercury, and organophosphates. (However for the latter the term biological effect monitoring is also used, as the test monitors the cumulative effect of organophosphate insecticides by measuring the level of cholinesterase inhibition.) 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.

3.4 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.

3.5 Legal requirements

BEI are another tool that can be used in managing risks to health and safety associated with substances hazardous to health in the workplace. Exposure monitoring can include the monitoring of the conditions at the workplace as well as biological monitoring of people. BEI are guidance values for assessing biological monitoring results.

Under most circumstances worker biological monitoring will be classed as a health service. This means the rights and duties in the Code of Health and Disability Services Consumer's Rights (including consent requirements) will apply. See Code of Health and Disability Services Consumer's Rights for further information.

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

PES can also be prescribed in respect of BEI. If there is a BEI PES, regulations 29, 30 and 32 of the GRWM Regulations apply. That is, a PCBU commits an offence by exceeding a PES, failing to undertake exposure monitoring where they are uncertain on reasonable grounds about whether the concentration exceeds a PES or where the duties relating to exposure monitoring of PES are not complied with.

3.6 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.[10,11]

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-life 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.

3.7 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*[12]

b. *Industrial Chemical Exposure, Guidelines for Biological Monitoring.*[13]

3.8 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 BEI for some substances 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.)

[10] Paustenbach, D.J. 'The History and Biological Basis of Occupational Exposure Limits for Chemical Agents', *Patty's Industrial Hygiene and Toxicology*, 5th Edition, volume 3. John Wiley and Sons (2000).

[11] Lauwerys R.R. and Hoet P. *Industrial Chemical Exposure, Guidelines for Biological Monitoring*. 2nd Edition. ISBN: 0-87371-650-7, (1993).

[12] American Conference of Governmental Industrial Hygienists (ACGIH). *Documentation of the Threshold Limit Values and Biological Exposure Indices*. 7th Edition, ACGIH, Cincinnati, Ohio (2015).

[13] Industrial Chemical Exposure – Guidelines for Biological Monitoring, 3rd edition, R.R. Lauwerys, P. Hoet (2001).

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.

3.9 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 Worksafe.

4.0
BEI values

IN THIS SECTION:

4.1 Table of BEI values

The following table (Table 5) lists the BEI values set by WorkSafe.

EXPOSURE	DETERMINANT	SAMPLING TIME	BEI	NOTE	YEAR ADOPTED
Acetone	Acetone in urine	End of shift	50mg/litre		
Arsenic	Sum of inorganic arsenic compounds and its metabolites (MMA and DMA) in urine	End of work week. Dietary sources of arsenic should be considered in the sampling protocol	15µg/litre	carcinogen category 1; oto	2020
Benzene	S-Phenylmercapturic acid (S-PMA) in urine	End of shift	2µg/g creatinine	carcinogen category 1; skin	2020
Cadmium	Cadmium in urine	Not critical	2µg/g creatinine	To be assessed in conjunction with the WES-TWA for cadmium and cadmium compounds, as Cd; carcinogen category 1	2020
Carbon disulphide	2-Thioxothiazolidine-4-carboxylic acid (TTCA) in urine	End of shift	0.5mg/g creatinine	skin; oto	2018
Carbon monoxide	Carboxyhaemoglobin in blood	End of shift	3.5% of haemoglobin	oto	2018
Carbon monoxide	Carbon monoxide in exhaled air	As soon as practicable following potential exposure, using an appropriate purpose-designed breath analyser It is noted that breath samples taken more than 10 to 15 minutes after the end of exposure will be significantly lower than those taken immediately following exposure	20ppm	oto	2018
Chromium (VI) water-soluble fume	Total chromium in urine	End of shift at end of work week	25µg/litre	carcinogen category 1; dsen for all chromium (VI) compounds except barium, lead and poorly soluble zinc chromates; skin for all water-soluble (≥500g/L) chromium VI compounds; rsen	2018
Chromium (VI) water-soluble fume	Total chromium in urine	End of 8-hour exposure	Increase of 10µg/litre	carcinogen category 1; dsen for all chromium (VI) compounds except barium, lead and poorly soluble zinc chromates; skin for all water-soluble (≥500g/L) chromium VI compounds; rsen	2018

EXPOSURE	DETERMINANT	SAMPLING TIME	BEI	NOTE	YEAR ADOPTED
Cobalt	Cobalt in urine	End of shift at end of work week	15µg/litre	carcinogen category 2; skin; oto; sen	
2-Ethoxyethanol and 2-Ethoxyethyl acetate	2-Ethoxyacetic acid in urine	End of shift at end of work week	100mg/g creatinine	skin	
Ethyl benzene	Sum of mandelic acid and phenylglyoxylic acids in urine	End of shift or end of exposure	0.25g/g creatinine	oto	2018
Fluorides	Fluoride in urine	Prior to shift	2mg/litre	– The BEI is not applicable to non-metal fluorides and organic fluoride-containing compounds – As dietary and environmental factors can vary the fluoride body concentrations, repeated measurements are necessary – Biological levels of fluorides are indicators of the potential risk of systemic toxicity and cannot be used for the evaluation of irritative effects	2018
Fluorides	Fluoride in urine	End of shift	3mg/litre	– The BEI is not applicable to non-metal fluorides and organic fluoride-containing compounds – As dietary and environmental factors can vary the fluoride body concentrations, repeated measurements are necessary – Biological levels of fluorides are indicators of the potential risk of systemic toxicity and cannot be used for the evaluation of irritative effects	2018
n-Hexane	2,5-hexanedione in urine	End of shift	5mg/litre	oto	

EXPOSURE	DETERMINANT	SAMPLING TIME	BEI	NOTE	YEAR ADOPTED
Lead (inorganic)	Lead in blood	Not critical	10µg/dL (0.48µmol/L) for males and for females not of reproductive capacity, pregnant, or breastfeeding Biological Agent Reference Value (BRV) for lead in whole blood of females of reproductive capacity, pregnant, or breastfeeding of 3µg/dL (0.14µmol/L)	oto Ideally, pregnant women, breastfeeding women, or women planning to become pregnant should have no exposure to lead at all. This is because the developing foetus is extremely susceptible to lead The BRV is based on the 95th percentile blood lead levels of women aged 18–69 in New Zealand. The BRV is not a BEI and is intended only to be an indicator that workplace exposure may exist and should be investigated as there is no recognized threshold for neurotoxicity for new-borns and infants Management of suspension of a worker and return to work based on biological monitoring should be supervised by a competent medical practitioner	2022
Mercury	Mercury in urine	Prior to shift	20µg/g creatinine	skin; dsen; oto	2018
Methyl alcohol	Methyl alcohol in urine	End of shift	15mg/litre	skin	
Methyl ethyl ketone (MEK)	MEK in urine	End of shift	2mg/litre		
4,4-Methylene bis(2- chloroaniline) (also known as 2,2'-dichloro-4,4'-methylene dianiline, MOCA, MBOCA)	Total MBOCA in urine (following alkaline hydrolysis)	End of shift	Minimum detection limit of the analytical method	carcinogen category 1; skin	2018

EXPOSURE	DETERMINANT	SAMPLING TIME	BEI	NOTE	YEAR ADOPTED
4,4-Methylene diphenyl diisocyanate (MDI) (also known as 4-4-Methylene bisphenyl isocyanate)	4,4-Diaminodiphenyl in urine (following hydrolysis)	End of shift or end of exposure	10µg/g creatinine	sen	2018
Methyl isobutyl ketone (MIBK)	MIBK in urine	End of shift	0.7mg/litre		2018
Organophosphates and other cholinesterase inhibiting substances	Cholinesterase activity in blood		**Recommended action**: If less than 60% of Baseline: suspend from working with substances which inhibit cholinesterase activity. If less than 80% of Baseline: repeat test to confirm result. If greater than 75% of Baseline: permit a previously suspended worker to recommence normal duties		
Pentachlorophenol (PCP)	PCP in urine (following acid hydrolysis)	Prior to last shift of work week	Minimum detection limit of the analytical method	carcinogen category 2; skin	2018
Phenol	Total phenol in urine	End of shift	100mg/L	skin	2020
Sodium fluoroacetate (1080)	Sodium fluoroacetate in urine	End of shift	15µg/litre		
Styrene	Mandelic acid plus phenylglyoxylic acid in urine	End of shift	400mg/g creatinine	carcinogen category 2; oto	2019
Styrene	Styrene in urine	End of shift	40µg/litre	carcinogen category 2; oto	2019
Tetrahydrofuran (THF)	THF in urine	End of exposure or shift (within 1 hour of end of exposure)	2mg/g creatinine	carcinogen category 2; skin	2018

EXPOSURE	DETERMINANT	SAMPLING TIME	BEI	NOTE	YEAR ADOPTED
Toluene	Toluene in urine	End of exposure or end of shift	0.03mg/litre	oto; skin	2018
Toluene	o-Cresol in urine (following hydrolysis)	End of exposure or end of shift	0.3mg/g creatinine	oto; skin	2018
Toluene diisocyanate-2,4- or 2,6- or a mixture of isomers (TDI)	Toluene diamine in urine (with acid hydrolysis)	End of work shift	5µg/g creatinine	dsen; rsen	2018
Trichloroethylene (TCE)	Trichloroacetic acid in urine	End of shift at end of work week	15mg/litre	carcinogen category 1; oto	2018
Xylene	Methylhippuric acid in urine	End of shift	1.5g/litre	oto	

TABLE 5: Biological exposure indices

Appendices

IN THIS SECTION:

Appendix 1: Glossary

TERM	DEFINITION
ACGIH®	The American Conference of Governmental Industrial Hygienists (ACGIH®) is a 501(c)(3) charitable scientific organization, established in 1938, that advances occupational and environmental health. Examples of this include their annual edition of the TLVs® and BEIs® book and Guide to Occupational Exposure Values.
Agglomeration	A mass or cluster.
Allergenic	A term applied to a substance that can cause an allergic response (development of an allergy to it, with allergic symptoms on re-exposure).
Allergic sensitisation	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 sensitivity reaction may occur.
Animal studies	Also known as 'Animal Testing': the practice of using animals in experiments, including for biomedical research or toxicology testing.
Airborne contaminants	Potentially toxic dusts, fibres, fumes, mists, vapours or gases contaminating the air.
Background level	Level of a substance in a worker's biological sample that can occur naturally (without any workplace exposure). The background level can be due to the substance's normal presence in the environment or diet, or produced in the body itself.
bio	Exposure can also be estimated by biological monitoring.
Biological agent reference value (BRV)	Based on the 95th percentile in the general New Zealand population.
Biological assay	Also known as Bioassay, it is a particular type of test or experiment designed to determine the presence and/or concentration of a substance.
Biological exposure index (BEI)	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.
Carboxyhaemoglobin level	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.
carcinogen category 1	Known or presumed human carcinogen.
carcinogen category 2	Suspected human carcinogen.
Carcinogenic	The description given to those hazardous/toxic substances that can cause cancer or contribute to its development.
CAS #	Short for Chemical Abstract Services Registry Number. This Registry assigns a unique identifying series of numbers to each individual chemical.
Causal relationship	The relationship between an event and another event, where the second event is a consequence of the first, for example, exposure to a confirmed cancer-causing agent may, depending on the extent of the exposure, lead to cancer in the exposed person.
Ceiling (WES-Ceiling)	A concentration that should not be exceeded at any time during any part of the working day.
dL	Decilitre. Its volume is one tenth of a litre or 100 millilitres.
Dusts	Discrete solid particles suspended in air. See section on Aerosols for a more detailed definition.
Elimination rate	The calculated (or estimated) rate at which a substance is eliminated from the body.
Epidemiological studies	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.
Aerodynamic equivalent diameter (AED)	The diameter of a sphere of 'unit density' (1 gram per cm^3) that exhibits the same aerodynamic behaviour as that of the particle (of any shape or density) being measured.

TERM	DEFINITION
Excursion limit (EL)	For many substances with a WES-TWA, there is no WES-STEL. Nevertheless, excursions above the WES-TWA should be controlled, even where the 8-hour WES-TWA is within the recommended limits. Excursion limits apply to those WES-TWAs that do not have WES-STELs. Transient increases in workers' exposure levels may exceed three times the value of the WES-TWA level for no more than 15 minutes at a time, on no more than four occasions spaced one hour apart during a workday, and under no circumstances should they exceed five times the value of the WES-TWA level. In addition, the 8-hour TWA is not to be exceeded for an 8-hour work period.
Fibrogenic	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 scarring.
Fume	Very small airborne solid particulates with diameters generally less than 1μm. They may be formed by thermal mechanisms (for example, condensation of volatilised solids, or incomplete combustion) or chemical processes (for example, vapour phase reactions). Agglomeration of fume particles may occur, resulting in the formation of much larger particles.
Gas	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 (for example, argon) but more usually comprise molecules, containing more than one atom of one or more elements (for example, carbon dioxide).
GRWM Regulations	Health and Safety at Work (General Risk and Workplace Management) Regulations 2016.
Hazardous substance	A substance (in gas, liquid or solid form) that has one, or more, of the following properties: – explosive – flammable – oxidising – toxic (harmful to humans) – corrosive – ecotoxic (harmful to animals, soil, water or air).
HSNO Act	The Hazardous Substances and New Organisms Act 1996.
HSWA	Health and Safety at Work Act 2015.
Infectious	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.
Inhalable dust	Portion of airborne dust that is taken in through the mouth and nose during breathing.
Irritative	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).
Latency period	The period between contact with a chemical substance or biological pathogen and the development of symptoms.
Metabolism	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/m³	mg = milligrams, and m³ = cubic metres. mg/m³ is used for reporting the concentration of solids (like dusts or metal fume) 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 are usually reported in ppm.
oto	A substance that can cause hearing loss either in conjunction with noise exposure, or without concurrent noise exposure

TERM	DEFINITION
PES	A prescribed workplace exposure standard or biological exposure index that has the purpose of protecting persons in a workplace from harm to health. PES must be complied with (and is not merely a guidance value like WES). PES are prescribed in: (i) regulations (ii) a safe work instrument, or (iii) the Hazardous Substances and New Organisms Act 1996 as a control under section 77 or 77A, or an exposure limit under section 77B or a group standard approval issued under section 96B.
Pharmacokinetics (or toxicokinetics)	Pharmacokinetics describes the movement of a substance through the body. It includes the processes of absorption, distribution, modification, and elimination of the substance.
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.
Respirable dust	The fraction of total inhalable dust that is able to penetrate and deposit in the lower bronchioles and alveolar region of the lungs.
Respiratory system	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.) The main organs and structures involved in the respiratory system are: – nose – pharynx – larynx – trachea, bronchi and lungs – pleura (membrane surrounding lungs) – blood and nerve supply.
Rubber fume	Any fume that evolves during the blending, milling and curing of natural rubbers or synthetic elastomers.
Rubber process dust	Dust generated during the manufacture of goods using natural rubber or synthetic elastomers.
Safety data sheet	A document that describes the hazardous properties of a substance, that is, its identity, chemical and physical properties, health hazard information, precautions for use and safe handling information.
SCOEL	The Scientific Committee on Exposure Limit Values (SCOEL) is a committee of the European Commission established in 1995 to advise on occupational exposure limits for chemicals in the workplace within the framework of Directives 98/24/EC and 90/394/EEC.
Short-term exposure limit (WES-STEL)	The 15-minute time weighted average 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. Exposures at concentrations between the WES-TWA and the WES-STEL should be less than 15 minutes, should occur no more than four times per day, and there should be at least 60 minutes between successive exposures in this range.
sen	A substance that can 'sensitise' the 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 exposure to it.
skin	Skin absorption–applicable to a substance that is capable of being significantly absorbed into the body through contact with the skin.
Substance	A substance identified in this document that has properties making it toxic to human health.
Synergistic effect	This occurs when the combined effect of two chemicals is substantially greater than the sum of the effects of each chemical on their own (for example, 2 + 4 = 20 (not 6, which would be a simple additive effect).

TERM	DEFINITION
Terminal velocity	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.
Time-weighted average (WES-TWA)	The average airborne concentration of a substance calculated over an eight-hour working day.
Vapour	A vapour is the gaseous form of a substance which at normal temperature and pressure exists predominantly as a liquid or solid. This distinguishes it from compounds which exist as gases at room temperature.
μm	Micrometre, or 'micron'. Its size is 1 millionth of a metre.
μg	Microgram. It is a unit of mass equal to 1 millionth of a gram or 1 thousandth of a milligram.
μmol	Micromole, a unit of measurement for the amount of substance, or chemical amount.
Unciliated airways	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) there are no cilia.
Worker's breathing zone	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.
Workplace exposure standard (WES)	Workplace exposure standards are values that refer 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.

Notes

Disclaimer

This publication provides general guidance. It is not possible for WorkSafe to address every situation that could occur in every workplace. This means that you will need to think about this guidance and how to apply it to your particular circumstances.

WorkSafe regularly reviews and revises guidance to ensure that it is up-to-date. If you are reading a printed copy of this guidance, please check worksafe.govt.nz to confirm that your copy is the current version.

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