SPECIAL GUIDE

Workplace exposure standards and biological exposure indices

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WORKSAFE
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Preface

The thirteenth 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			
30,70	Acrylonitrile (Vinyl cyanide)	Introduction of (oto) notation	Acrylonitrile is a known ototoxin.
32, 80	Arsenic and soluble compounds	Introduction of (oto) notation	Arsenic is a known ototoxin.
36, 80	Carbon disulphide	Introduction of (oto) notation	Carbon disulphide is a known ototoxin.
41	1,1-dichloroethane	Change of WES-TWA to 100ppm Retain WES-STEL of 250ppm	The WES-TWA is set to protect exposed workers from potential ocular and upper respiratory tract irritation, and possible liver, kidney, and CNS effects.
45,48	2-Ethoxyethanol (Glycol monoethyl ester)	Change of WES-TWA to 2ppm	The WES-TWA is set to protect exposed workers from potential haematological, reproductive and developmental effects.
45	2-Ethoxyethyl acetate (EGEEA)	Change of WES-TWA to 2ppm	The WES-TWA is set to protect exposed workers from potential haematological, reproductive and developmental effects.
36	Caprolactam (dust and vapour)	Removal individual WES-TWA and WES-STEL for dust and vapour and change to a combined WES-TWA of 5mg/m^3 (total, vapour and particulate) and a WES-STEL of 10mg/m^3 (total, vapour and particulate) Removal of (dsen) notation	The WES-TWA is set to protect exposed workers from potential mucous membrane, respiratory tract and skin irritation. The WES-STEL is set to protect exposed workers from potential peak concentrations initiating irritation. Available information indicates that caprolactam is not a sensitiser (ACGIH®, 2003), and a sen notation is not warranted.
36	Carbon monoxide	Change of WES-TWA to 20ppm Change of WES-STEL to 100ppm Change of WES-Ceiling to 200ppm Introduction of (oto) notation	The WES-TWA is set to prevent blood carboxyhaemoglobin concentrations in excess of 3.5% and the associated adverse neurobehavioral and cardiovascular effects in otherwise healthy workers. Reports were also noted of decreased exercise stamina in healthy adults, and neurobehavioral/cognitive changes at ≥ 30ppm (≥ 5% carboxyhaemoglobin). The WES-Ceiling is set to protect exposed workers from potential accumulation of carboxyhaemoglobin from peak concentrations. Carbon monoxide is a known ototoxin.

PAGE	TOPIC	CHANGES	RATIONALE
39	Cobalt metal	Introduction of (oto) notation	Cobalt metal is a known ototoxin.
39	Cyanamide	Change of WES-TWA to 0.2mg/m^3 aerosol and vapour Introduction of (skin) notation	The WES-TWA is set to protect exposed workers from potential eye and skin irritation, and effects on the male reproductive system. A 'skin' notation appears justified for cyanamide, due to the reported data on the potential significance of dermal absorption from contact with cyanamide
40	Dibutyl phthalate	Change of WES-TWA to 0.05ppm	The WES-TWA is set to protect exposed workers from potential respiratory tract irritation, and reproductive and developmental effects.
42	Diesel fuel	Introduction of WES-TWA of 100mg/m^3 total hydrocarbons, inhalable fraction and vapour Introduction of (skin) notation	The WES-TWA is set to protect exposed workers from potential CNS impairment and liver, lung and kidney damage and is based on reports of subtle CNS effects (rotorod test of diesel vapor in rodents that occur at and above 135mg/m^3). A skin notation is justified for diesel fuel, due to the reported systemic toxicity in experimental animals and humans after dermal exposures to hydrocarbon mixtures.
42	Diethylamine	Change of WES-TWA to 2ppm Change of WES-STEL to 5ppm Removal of (dsen) notation	The WES-TWA is set to protect exposed workers from eye, skin and respiratory tract irritation/ corrosion. The WES-STEL is set to protect exposed workers from potential peak concentrations initiating irritation reactions. Available information indicates that diethylamine is not a sensitiser, due to its corrosive properties (DFG, 2018), and a sen notation is not warranted.
42	Diethylene glycol	Change of WES-TWA to 10ppm aerosol and vapour Introduction of WES-STEL of 40ppm aerosol and vapour	The WES-TWA is set to protect exposed workers from metabolic acidosis, and kidney and liver damage. Converting from oral exposure in rats to inhalation exposure in workers gives a factor of 50 from the NOAEL of 300mg/kg b.w./day from the Gaunt et al. (1976) data to the WES-TWA, accounting for the apparent sensitivity of humans vs rats (interspecies variation); interindividual variation; and, the use of a sub-acute NOAEL for a chronic endpoint. The WES-STEL is set to protect exposed workers from potential peak concentrations initiating systemic effects, due to the estimated 4-hour plus half-lives of key diethylene glycol metabolites.
43	Dimethylamine	Change of WES-TWA to 2ppm Removal of (dsen) notation	The WES-TWA is set to protect exposed workers from eye, skin and respiratory tract irritation/ corrosion, and central nervous system depression. Available information indicates that dimethylamine is not a sensitiser, due to its corrosive properties (ECHA REACH, 2020), and a sen notation is not warranted.
43	Dimethylformamide	Change of WES-TWA to 5ppm	The WES-TWA is set to protect exposed workers from potential systemic effects: liver damage and developmental toxicity.
43,44	Dinitolmide (3,5-Dinitro-o-toluamide)	Change of WES-TWA to 1mg/m^3	The WES-TWA is set to protect for liver damage in exposed workers.

PAGE	TOPIC	CHANGES	RATIONALE
44	Diquat	Change of WES-TWA to 0.5mg/m^3 inhalable fraction to include all forms of diquat including diquat bromide Introduction of WES-TWA of 0.1mg/m^3 respirable fraction for all forms of diquat Introduction of (skin) notation	The WES-TWA are set to protect exposed workers from potential local effects: eye, skin, respiratory tract, and lung irritation; and, cataract development. A skin notation is justified for diquat to flag the possibility in accidental/extreme exposures.
45	Ethyl benzene	Change of WES-TWA to 20ppm Change of WES-STEL to 40ppm Introduction of (oto) notation Introduction of (skin) notation	The WES-TWA is set to protect exposed workers from potential irritation, organ damage and hearing loss. The WES-STEL is set to protect exposed workers from potential peak concentrations initiating liver cell proliferation. A skin notation is justified for ethylbenzene, due to the reported potential significance of dermal absorption from contact with ethylbenzene. Ethyl benzene is a known ototoxin.
45	Ethanol (Ethyl alcohol)	Introduction of (oto) notation	Ethanol (Ethyl alcohol) is a known ototoxin.
47	Formaldehyde	Adoption of interim WES-TWA of 0.3ppm and WES-STEL of 0.6ppm	The WES-TWA and WES-STEL is set to protect exposed workers from sensory irritation and undue annoyance based on the SCOEL recommendations.
48	Heptane	Introduction of (oto) notation	Heptane is a known ototoxin.
49	Hexane (n-Hexane)	Introduction of (oto) notation	Hexane (n-Hexane) is a known ototoxin.
49	Hydrogen cyanide	Change of WES-Ceiling to 5ppm Introduction of WES-TWA of 1ppm Introduction of (oto) notation	The WES-TWA and WES-Ceiling are set to protect against neurological effects, thyroid damage and respiratory tract irritation from acute and chronic inhalation exposures, based on the SCOEL recommendations. Hydrogen cyanide and its salts are known ototoxins.
50	Iodine	Introduction of WES-TWA of 0.01ppm	The WES-TWA is set to protect exposed workers from adverse thyroid effects (and sequelae, including reproductive and developmental effects).
51	Isocyanates	Retain current WES-TWA of 0.02mg/m^3 (all isocyanates vapour, mist or dust) Retain current WES-STEL of 0.07mg/m^3 (all isocyanates vapour, mist or dust)	The WES-TWA is retained as an interim and is proposed to be changed to 0.0001 in 2022. The WES-STEL is is retained as an interim and is proposed to be changed to 0.0005 in 2022.
52	Lead, inorganic dusts and fumes	Introduction of (oto) notation	Lead is a known ototoxin.
53	Manganese fume, dust and compounds	Introduction of (oto) notation	Manganese is a known ototoxin.
53	Mercury	Introduction of (oto) notation	Mercury is a known ototoxin.

PAGE	TOPIC	CHANGES	RATIONALE
54	Methyl acrylate	Change of WES-TWA to 2ppm Introduction of WES-STEL of 4ppm	The WES-TWA is set to protect exposed workers from eye, skin and respiratory tract irritation. The WES-STEL is set to protect exposed workers from potential peak concentrations initiating irritation reactions.
55	α-Methyl styrene	Introduction of (oto) notation	α-Methyl styrene is a known ototoxin.
54	Methyl bromide	Change of WES-TWA to 1ppm Introduction of WES-STEL of 2ppm	The WES-TWA is set to protect exposed workers from potential skin, eye and respiratory tract irritation, and neurotoxicity. In the absence of robust quantitative exposure data from workplace studies, the proposed WES-TWA is informed by quantitative data from animal models, with their inherent limitations (for example, interspecies differences in respiratory tract structure and function); noting the differences in methyl bromide metabolism between species; and, the reported theta GST enzyme polymorphism in humans and variation in neurotoxic response in exposed workers. The WES-STEL is set to protect exposed workers from potential peak concentrations initiating irritation effects, noting the reported steep dose-response curve for systemic neurotoxicity.
54,67	Methyl chloroform (1,1,1-Trichloroethane)	Change of WES-TWA to 100ppm Introduction of WES-STEL of 200ppm Introduction of (skin) notation	The WES-TWA is set to protect exposed workers from potential systemic toxicity: pre-narcotic/anaesthetic effects. The WES-STEL is set to protect exposed workers from potential local toxic effects: skin irritation, dermatitis and objectionable odours. A skin notation is justified for methyl chloroform, due to the reported rate of dermal absorption from contact with liquid methyl chloroform (DFG, 2019; ATSDR, 2006). Biological monitoring of workers is recommended to assess total exposures to methyl chloroform and potential health risks.
55	Methylamine	Change of WES-TWA to 5ppm Introduction of WES-STEL of 10ppm	The WES-TWA is set to protect exposed workers from potential local effects: eye, skin and respiratory tract irritation from repetitive exposure. The WES-STEL is set to protect exposed workers from potential local effects: eye, skin and respiratory tract irritation.
57	Nitrobenzene	Change of WES-TWA to 0.1ppm	The WES-TWA is set to protect exposed workers from potential methaemoglobin formation and sequelae. The WES-TWA is also set to protect against any carcinogenic effects by non-genotoxic mechanisms.
–	Nitroglycerin (NG)	Remove entire entry	Nitroglycerin (NG) is not an approved substance in New Zealand and is not in use to our knowledge. Therefore, a WES is not required.
40	o-Dichlorobenzene	Removal of WES-Ceiling of 50ppm Introduction of WES-TWA of 10ppm Introduction of WES-STEL of 20ppm Removal of (skin) notation	The WES-TWA is set to protect exposed workers from potential skin, eye and respiratory tract irritation, and liver damage. The human equivalent NOAECs of 105 and 120mg/m^3 (17 and 20ppm) indicate a factor of 2 to the proposed WES-TWA. The WES-STEL is set to protect exposed workers from potential peak concentrations initiating skin, eye and respiratory tract irritation. A skin notation is not justified for o-dichlorobenzene, due to the lack of reported potential significance of dermal absorption from contact with o-dichlorobenzene (ATSDR, 2006; ACGIH®, 2001; Safe Work Australia, 2019).

PAGE	TOPIC	CHANGES	RATIONALE
60,68	Picric acid (2,4,6-trinitrophenol)	Introduction of WES-STEL of 0.2mg/m^3 Introduction of (skin) notation	The WES-STEL is set to protect exposed workers from potential peak concentrations initiating irritation reactions. A skin notation may be justified for picric acid, based on structural similarities with substances known to penetrate the skin (DFG MAK, 2002). However, the irritant/corrosive nature of picric acid is likely to limit dermal contact.
59,64, 70	Phenylethylene (Styrene monomer; Vinyl benzene)	Introduction of (oto) notation	Phenylethylene (Styrene monomer; Vinyl benzene) is a known ototoxin.
66	Tetrahydrofuran	Change of WES-TWA to 50ppm Introduction of a WES-STEL of 100ppm	The WES-TWA is set to protect exposed workers from potential respiratory tract irritation, CNS effects, liver and kidney damage, and, if relevant, tumour induction. The WES-STEL is set to protect exposed workers from potential peak concentrations initiating respiratory tract irritation or CNS effects, and, if relevant, tumour induction.
67	Tin, Organic compounds	Introduction of (oto) notation	Organic tin compounds are known ototoxins.
67	Toluene (Toluol)	Change of WES-TWA to 20ppm Introduction of WES-STEL of 100ppm Introduction of (oto) notation	The WES-TWA is set to protect exposed workers from potential neurotoxicity, and abortion in female workers. It is noted that the proposed WES-TWA of 20ppm may not be protective for individuals with increased sensitivity to chemicals or with genetic factors that limit the effectiveness of key detoxification enzymes. The WES-STEL is set to protect exposed workers from potential neurotoxicity, based on the NOAEL of 110ppm. Toluene (Toluol) is a known ototoxin.
67	Trichloroethylene	Introduction of (oto) notation	Trichloroethylene is a known ototoxin.
69	Turpentine	Change of WES-TWA to 5ppm (turpentine and monoterpenes) Introduction of WES-STEL of 10ppm (turpentine and monoterpenes) Introduction of (skin) notation	The WES-TWA is set to protect exposed workers from potential mucous membrane and respiratory tract irritation, and long-term respiratory effects, noting the reported real-world LOAEC of 10ppm. The WES-STEL is set protect exposed workers from potential peak concentrations initiating irritation effects, noting the reported real-world LOAEC of 10ppm. A skin notation is justified for turpentine and monoterpenes, due to the reported potential significance of dermal absorption from skin contact (DFG MAK, 2019).
70	Welding fume	Removal of WES-TWA of 5mg/m^3	The removal of the WES-TWA for welding fume is based on the heterogeneous nature of welding fumes, the carcinogenic classification of many of its components, and its classification as a known carcinogen by IARC. Exposure assessment of welding fume should therefore be based on a risk assessment of known or expected components in welding fume, which would include metal fume as well as shielding gases and contaminants produced during combustion of surface coatings and cleaning products, where present.
71	Xylene (o-, m-, p-isomers)	Introduction of (oto) notation	p-Xylene is a known ototoxin.

PAGE	TOPIC	CHANGES	RATIONALE
TABLE 5			
82	Lead BEI	Removal of BEI for lead in whole blood of 20μg/dL (0.97μmol/L) Introduction of Biological Agent Reference Value (BRV) for lead in whole blood of females of reproductive capacity at 3μg/dL (0.14μmol/L) Introduction of BEI for lead in whole blood of all other workers at 10μg/dL (0.48μmol/L) Removal of suspension levels	Blood lead in females of reproductive capacity exceeding the population 95th percentile is an indicator that workplace exposure may exist and should be investigated as ideally pregnant women, breastfeeding women, or women planning to become pregnant should have no exposure to lead at all. The BEI for all other workers (that is, not females of reproductive capacity) is set to protect against neurotoxicity and neurobehavioral effects including transient neurological effects that may impact safety and permanent health effects based on information from ACGIH® and DFG. Suspension (removal) of workers should be determined by a suitably qualified medical practitioner and should consider the BEI and BRV as factors in determining risk.

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 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 HSWA and the HSNO Act may use this book 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 determine 'compliance'. Professional judgement is required in making decisions regarding safe levels of exposure to chemical and physical agents found in the workplace.

Legal requirements

WES are an important tool for monitoring the workplace environment. Where hazardous or toxic substances exist in the same environment as workers, and the PCBU is unable to successfully eliminate these substances from working environments, they are required to minimise and monitor worker exposure. The PCBU must also, so far as is reasonably practicable, ensure that the health of workers and the conditions at the workplace are monitored for the purpose of preventing injury or illness of workers arising from the conduct of the business or undertaking.

Section 36 of HSWA requires PCBUs to ensure worker health and safety 'so far as is reasonably practicable'. That duty requires the PCBU to eliminate risks to health and safety, so far as is reasonably practicable. If it is not reasonably practicable to do so, the PCBU must minimise the risks so far as is reasonably practicable. If a PCBU is uncertain on reasonable grounds whether the concentration of a substance exceeds the relevant prescribed exposure standard, regulation 30 of GRWM Regulations requires the PCBU to conduct exposure monitoring to determine the concentration of the substance. Regulation 32 of the GRWM Regulations requires the PCBU to make the results of exposure monitoring available to any person in the workplace who may have been exposed to the health hazard provided that no information that identifies an individual worker is disclosed. A prescribed exposure standard is 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:

a. Regulations

b. A safe work instrument.

Regulation 8 of the GRWM Regulations requires the 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.

In workplaces where a worker is carrying out ongoing work involving a substance that is hazardous to health that is specified in a safe work instrument as requiring health monitoring, regulation 31 of the GRWM Regulations requires the PCBU to ensure that health monitoring is provided to the worker if there is a serious risk to the workers' health because of exposure to the substance. Regulation 39 requires the PCBU to give results of health monitoring of a worker to that worker.

Limitations

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

WES must not be used to differentiate between safe and inherently hazardous exposure levels. In addition, the numerical value of two or more WES must not be used to directly compare the relative toxicity of different substances 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 that could be more appropriate to apply for the purposes of managing health risk. Relevant sources of other exposure standards include the Gestis substance database, the ACGIH®, SCOEL, ECHA, DFG, DECOS, and Safe Work Australia.

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 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 1.8).

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.

It is recommended 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: https://register.hasanz.org.nz

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:

- NIOSH[1] Occupational exposure sampling strategy manual (1977)
- at least one employee in five from a properly selected SEG (UK Health and Safety Executive HSG173 (2006)[2]
- 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)[3]
- 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)[3]
- South African Mines Occupational Hygiene Programme – sample 5% of workers in an SEG[4]
- 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 2006) (source W501 OH Learning, Measurement of Hazardous Substances, 2009).[5]
- European Standard EN 689:2018 ‘Workplace exposure – Measurement of exposure by inhalation to chemical agents – Strategy for testing compliance with occupational exposure limits’.

1 The National Institute for Occupational Safety and Health (NIOSH) Publication 77–173 *Occupational exposure sampling strategy manual* (1977).

2 UK Health and Safety Executive HSG173 Monitoring strategies for toxic substances (2006).

3 OH Learning W501 Measurement of Hazardous Substances. www.OHlearning.com (2009).

4 South African Mines Occupational Hygiene Programme codebook (SAMOHP) (2002).

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

Statistical analysis of sampling results

Multiple 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 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 WES are complied with
- 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 compliance with WES and assess risk. For example, the mean (average) exposure calculated may be below a WES, but random variation, sampling and analytical error will introduce some uncertainty around that average. This uncertainty can be described as confidence limits around the average. If the upper confidence limit exceeds the WES, it indicates less certainty around whether the average exposures truly fall below the WES. If the upper confidence limit gives us 95% confidence that the 'true' average falls comfortably below the WES, then that provides a high level of certainty that exposures comply with the WES.

Useful tools for statistical analysis of occupational hygiene samples include:

- 'IHStats' spreadsheet developed by the American Industrial Hygiene Association: www.aiha.org/public-resources/consumer-resources/topics-of-interest/ih-apps-tools
- European Standard EN 689:2018 'Workplace exposure – Measurement of exposure by inhalation to chemical agents – Strategy for testing compliance with occupational exposure limits'.
- 'Occupational Exposure Sampling Strategy Manual', DHHS (NIOSH) Publication Number 77–173, 1977: www.cdc.gov/niosh/docs/77-173/pdfs/77-173.pdf
- AIOH Occupational Hygiene Monitoring and Compliance Strategies (AIOH, 2014).
- 'Testing Compliance with Occupational Exposure Limits for Airborne Substances' BOHS/NVvA , 2014: www.arbeidshygiene.nl/-uploads/files/insite/2011-12-bohs-nvva-sampling-strategy-guidance.pdf

Which statistics to use for comparison with WES

Average (mean) exposure level is the appropriate parameter for evaluating cumulative exposure for substances that present a long term health risk. In this case the WES-TWA is the appropriate criteria for comparison. The average exposure will usually be calculated as a geometric mean rather than an arithmetic mean, as occupational hygiene exposures are usually log-normally distributed rather than normally (bell curve) distributed. It is necessary to assess the type of distribution so that the correct statistical parameters are used. Confidence limits around the mean should be considered when comparing the result to the WES. Peak or high exposures should also be reviewed as part of the risk assessment. Eliminating or reducing peak, or occasional high exposures may produce a significant reduction in average exposure levels.

The 95% upper confidence limit (UCL), and the upper tolerance limit (UTL) (that is, the 95% UCL of the 95th percentile of the results) are the appropriate parameters for evaluating exposure to substances that present an acute health risk. In this case the WES-STEL, WES-Ceiling or WES-EL are the appropriate criteria for comparison.

Compliance with WES

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.
- The criteria for setting a specific WES may be for a different health outcome than the risk being assessed. For example the WES may be based on reducing risk of irritation, however risk of more serious adverse effects may be the focus of the health risk assessment, therefore the WES may not be a stringent enough guideline to use in this case.
- Compliance 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 assessing compliance with WES isn't necessarily a straight forward process of comparing a sample result, or an average, to a WES.

Various organisations have developed guidelines to address this issue of how to assess WES compliance and whether further control of exposure needs to occur. Organisations that have developed guidance include the British and Netherlands Occupational Hygiene Societies (BOHS/NOHS), the American Industrial Hygiene Association (AIHA), the International Council on Mining and Metals (ICMM), and Utrecht University. A summary of their approaches is given below, but for more detail their documents should be referred to:

- BOHS/NOHS[6] – Assumes a WES may be regarded as complied with if, with 70% confidence, <5% of the exposures in the SEG exceed the WES. An individual worker's exposure complies if there is <20% probability that >5% of their exposure exceeds the WES.
- AIHA[7] – Has a rating scheme that categorises exposures as trivial (very low), highly controlled, well controlled, controlled, poorly controlled based on the estimated 95th percentile of the exposure distribution.
- ICMM[8] provides guidance on rating exposures (for example, if a result is less than 50% of the WES), exposures are well controlled below the WES. Results between 50% to 100% of the WES indicate there is potential for breaches of the WES.
- The Utrecht University[9], Institute for Risk Assessment Sciences SPEED (statistical program for the evaluation of exposure data) Excel application assesses whether the within-worker and between-worker exposures are acceptable in relation to the WES. It provides a stepwise approach to the sampling and statistical analysis of data.

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.

6 British Occupational Hygiene Society and the Netherlands Occupational Hygiene Society, *Testing Compliance with Occupational Exposure Limits for Airborne Substances* (2011).

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

8 International Council on Mining and Metals (ICMM) *Good Practice Guidance on Occupational Health Risk Assessment* (2007).

9 Utrecht University, Institute for Risk Assessment Sciences, Environmental and Occupational Health Division, Utrecht, The Netherlands Statistical Program for the Evaluation of Exposure Data www.iras.uu.nl/speed/#describe

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' (December 2010).

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:

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

Where h = hours worked per day

Seven day work week adjustment:

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

Where h = hours worked per week

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). Although some of the Quebec WES differ from New Zealand, the adjustment factor is provided in the model, thus that value can be applied to New Zealand WES. The model is available at: www.irsst.qc.ca/en/_outil_100011.html

C. 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

D. 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 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:

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

1.5 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 TLV 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.

1.6 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 1m. 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.

Equivalent aerodynamic diameter (EAD)

A parameter used to predict the likely behaviour of a particle in air is its Equivalent Aerodynamic Diameter (EAD). The equivalent aerodynamic diameter of a particle of any shape and density is defined as the diameter of a sphere with a density of $1.0 g/cm^3$ 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:

TABLE 1: Collection efficiency curve for inhalable dust

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

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*.[10]

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*.[11]

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

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

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 2: Collection efficiency curve for respirable dust

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

1.7 Carcinogenicity Category 1 or 2 (formerly 6.7) or other carcinogen notation

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, 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[12] 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.

1.8 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.

1.9 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.

[12] 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.

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 3:
Lung ventilation rates impacted by workload

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.

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.

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
CAS #	CAS Number, a unique numbering identifier is assigned by the Chemical Abstracts Service Registry to each individual chemical
ppm	Parts of vapour or gas per million of air by volume
mg/m^3	Milligrams of substance per cubic metre of air
(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
(om)	Sampled by a method that does not collect vapour
(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
(r)	The value for respirable dust
(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
carcinogen category 1	Known or presumed human carcinogen
carcinogen category 2	Suspected human carcinogen
(skin)	Skin absorption
(sen)	Sensitiser
(bio)	Exposure can also be estimated by biological monitoring
oto	Ototoxin
(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
(dsen)	Dermal sensitiser
(rsen)	Respiratory sensitiser

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 lower 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/m^3. Propose to change to WES-TWA of 0.2mg/m^3 in the year 2023 – Hydrogen sulphide: Interim WES-TWA of 5ppm and WES-STEL of 10ppm. Propose to change to WES-TWA of 1ppm and WES-STEL 5ppm in the year 2023 – Nitrogen dioxide: Interim WES-TWA of 1ppm. Propose to review WES again in the future – Silica-Crystalline (all forms): Interim WES-TWA of 0.05mg/m^3. Propose to review the WES again in the year 2023 – Vanadium, as V_2O_5: Interim WES-TWA 0.05mg/m^3, as V (I) for V and its inorganic compounds, except CI pigment yellow 184. Propose to review WES again in the future – Vinyl acetate: Interim WES-TWA 5ppm and WES-STEL 10ppm. Propose to review the WES again in the future – Wood dust, softwood: Interim WES-TWA of 2mg/m^3. Propose to change to WES-TWA of 1mg/m^3 in the year 2023 – Isocyanates, all, (as -NCO): Interim WES-TWA 0.02ppm and WES-STEL 0.07ppm. Propose to change in Nov 2022 to: WES-TWA 0.0001mg/m^3 WES-STEL 0.0005mg/m^3 with Skin notation
(sa)	Simple asphyxiant
(sax)	Simple asphyxiant – may present an explosion hazard

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]					5	21		[2022]
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]	0.1	0.23						[2022]
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
α Alumina (Aluminium oxide)	[1344-28-1]		10						
Aluminium oxide (α Alumina)	[1344-28-1]		10						
Aluminium, Metal dust (as Al)	[7429-90-5]		10						[2022]
Aluminium, Alkyls (not otherwise classified) (as Al)			2						[2022]

A		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Aluminium, Pyro powders (as Al)			5						[2022]
Aluminium, Soluble salts (as Al)			5						[2022]
Aluminium, Welding fumes (as Al)			5						[2022]
3-Amino-1,2,4-triazole (Amitrole)	[61-82-5]		0.2						
2-Aminoethanol (Ethanolamine)	[141-43-5]	3	7.5	6	15				[2022]
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
Anisidine (o-, p-isomers)	[29191-52-4]	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						

A		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
Antimony trioxide	[1309-64-4]		0.1					carcinogen category 2	2019
Argon	[7440-37-1]							sa	
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]		5						[2022]
Aspirin (Acetylsalicylic acid)	[50-78-2]		5						

A		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
Atrazine	[1912-24-9]		5						[2022]
Azinphos-methyl	[86-50-0]		0.2					skin; dsen	

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	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						

B		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
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						
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]	200	950						[2022]
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]	100	303	150	455				[2022]
n-Butyl glycidyl ether (BGE)	[2426-08-6]	0.25	1.33					skin; dsen	2019

B

Substance	CAS #	TWA ppm	TWA mg/m³	STEL ppm	STEL mg/m³	CEILING ppm	CEILING mg/m³	NOTATIONS [Notes]	YEAR ADOPTED [Next review]
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						
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

Substance	CAS #	TWA ppm	TWA mg/m³	STEL ppm	STEL mg/m³	CEILING ppm	CEILING mg/m³	NOTATIONS [Notes]	YEAR ADOPTED [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]		5						[2022]
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	

C		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
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						
Carbofuran	[1563-66-2]		0.1						
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						

C

		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
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		
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]	2	9.9					carcinogen category 2; skin	[2022]
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	

C		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
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				
Chlorosulphonic acid	[7790-94-5]		1						
o-Chlorotoluene	[95-49-8]	50	259						
Chlorpyrifos	[2921-88-2]		0.2					skin	
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; 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; †	2020
Chromium metal	[7440-47-3]		0.5					rsen	
Chromyl chloride	[14977-61-8]	0.025	0.16					dsen	[2022]
Chrysotile (see Asbestos)									
Coal dust			3(r)						
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	

C		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
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]	5	22					skin	[2022]
Cristobalite (see Silica-Crystalline)									2019
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, as CN	[151-50-8]; [143-33-9]		5					skin; dsen	2020
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						
Cyclohexylamine	[108-91-8]	10	41					dsen	[2022]
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	[94-75-7]		10					dsen	[2022]
Di(2-ethylhexyl)phthalate (Di-sec-octyl phthalate)	[117-81-7]		5		10				[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	
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	
Dibutyl phthalate	[84-74-2]	0.05	0.58						2022
2-N-Dibutylaminoethanol	[102-81-8]	2	14					skin	
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

D		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
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]	5	20	20	79				[2022]
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						
Dichlorotetrafluoroethane	[76-14-2]	1000	6990						
Dichlorvos	[62-73-7]	0.1	0.9					carcinogen category 2; skin; dsen	2019
Dicyclohexyl phthalate	[84-61-7]		5						
Dicyclopentadiene	[77-73-6]	5	27						[2022]
Dicyclopentadienyl iron	[102-54-5]		5						

D		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
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
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						

D		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Diisononyl phthalate	[28553-12-0]		5						
Diisopropylamine	[108-18-9]	5	21						
Dimethoxymethane (Methylal)	[109-87-5]	1000	3110						[2023]
Dimethyl acetamide	[127-19-5]	10	36						[2022]
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]	10	30	15	46				
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

D		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
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]		5		10				[2022]
Disulfiram	[97-77-8]		2					dsen	
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		2018
Ethanethiol (Ethyl mercaptan)	[75-08-1]	0.5	1.3						
Ethanol (Ethyl alcohol)	[64-17-5]	1000	1880					oto	2022
Ethanolamine (2-Aminoethanol)	[141-43-5]	3	7.5	6	15				[2022]
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
Ethyl acetate	[141-78-6]	200	720						
Ethyl acrylate	[140-88-5]					5	20	dsen	[2022]
Ethyl alcohol (Ethanol)	[64-17-5]	1000	1880					oto	[2022]
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	

E		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
Ethyl butyl ketone (3-Heptanone)	[106-35-4]	50	234						[2022]
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	
Ethylene glycol (vapour and mist)	[107-21-1]					50	127		[2023]
Ethylene glycol dinitrate	[628-96-6]	0.05	0.31					skin	[2022]
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

E

Substance	CAS #	TWA ppm	TWA mg/m³	STEL ppm	STEL mg/m³	CEILING ppm	CEILING mg/m³	NOTATIONS [Notes]	YEAR ADOPTED [Next review]
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

Substance	CAS #	TWA ppm	TWA mg/m³	STEL ppm	STEL mg/m³	CEILING ppm	CEILING mg/m³	NOTATIONS [Notes]	YEAR ADOPTED [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]	1	1.6	2	3.1				[2022]
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						

H

Substance	CAS #	TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
		ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
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]
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		[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

H		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
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	
Iron pentacarbonyl, as Fe	[13463-40-6]	0.1	0.23	0.2	0.45				
Iron salts, soluble, as Fe			1						
Isoamyl acetate	[123-92-2]	100	532						
Isoamyl alcohol	[123-51-3]	100	361	125	452				[2022]
Isobutyl acetate	[110-19-0]	150	713						[2023]
Isobutyl alcohol	[78-83-1]	50	152						

I		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Isocyanates, all, (as –NCO)			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
Hexamethylene diisocyanate	[822-06-0]								
Isophorone diisocyanate	[4098-71-9]								
MDI									
Diphenylmethane diisocyanate	[101-68-8]								
Methylene bisphenyl isocyanate									
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	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; bio	2022
Mercury, Inorganic compounds (as Hg)			0.025					skin; bio	[2021]
Mesityl oxide	[141-79-7]	15	60	25	100				[2022]
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	[2022]
Methomyl	[16752-77-5]		2.5						
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

M		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
4-Methoxyphenol	[150-76-5]		5					dsen	
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	[2022]
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]	50	103	100	207			skin	[2022]
Methyl chloroform (1,1,1-Trichloroethane)	[71-55-6]	100	555	200	1,110			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]	50	234						[2022]
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]	25	103	75	309			skin	[2022]
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	
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]	25	31						[2022]
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]	100	307						[2022]
Nitrogen	[7727-37-9]							sa	
Nitrogen dioxide	[10102-44-0]	1	1.9					†	2020 [2022]
Nitromethane	[75-52-5]	20	50					carcinogen category 2	
1-Nitropropane	[108-03-2]	25	91						[2022]
2-Nitropropane	[79-46-9]	5	19					carcinogen category 1	
Nitrotoluene	[88-72-2] [99-08-1] [99-99-0]	2	11					skin	
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	2120				
2-Pentanone (Methyl propyl ketone)	[107-87-9]	200	705	250	881				

P		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Perchloroethylene (Tetrachloroethylene)	[127-18-4]	20	136	40	271			carcinogen category 1; skin	2018
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	
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				[2022]
Phosphoric acid	[7664-38-2]		1						

P		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
Phosphorous (yellow)	[7723-14-0]		0.1						
Phosphorous oxychloride	[10025-87-3]	0.1	0.63						[2022]
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

P		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Potassium hydroxide	[1310-58-3]						2		
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	
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]	0.05	0.34					skin	[2022]
Propylene glycol monomethyl ether	[107-98-2]	100	369	150	553				

P		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Propylene oxide (1,2-Epoxypropane)	[75-56-9]	2	4.8					carcinogen category 2; dsen	2018
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)									2019 [2022]
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]		0.1						[2022]
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						
Silica-Crystalline (all forms)			0.05(r)					carcinogen category 1; α-quartz and cristobalite are confirmed carcinogens; †	2019 [2022]

S		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
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						
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	

S

		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
Sucrose	[57-50-1]		10						
Sulfotep (TEDP)	[3689-24-5]		0.2					skin	
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]	
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						

T		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
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	
Thallium soluble compounds, as Tl	[7440-28-0]		0.1					skin	[2022]
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	[7440-31-5]		2						[2022]

T		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
Tin, Organic compounds, as Sn			0.1		0.2			skin; oto	
Tin, Oxide and inorganic compounds, except SnH4, as Sn			2						
Titanium dioxide	[13463-67-7]		10						[2022]
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]	2	8.8					carcinogen category 2; skin; dsen	[2022]
Toluol (Toluene)	[108-88-3]	20	75	100	377			skin; oto; bio	2022
Tributyl phosphate	[126-73-8]	0.2	2.2						
1,1,2-Trichloro-1,2,2-trifluoroethane	[76-13-1]	1000	7670	1250	9590				[2023]
Trichloroacetic acid	[76-03-9]	1	6.7					carcinogen category 2	[2022]
1,2,4-Trichlorobenzene	[120-82-1]					5	37		
1,1,1-Trichloroethane (Methyl chloroform)	[71-55-6]	100	555	200	1,110			skin	2022
1,1,2-Trichloroethane	[79-00-5]	10	55					skin	[2022]
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

T		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
Trichloronitromethane (Chloropicrin, Nitrochloromethane)	[76-06-2]	0.1	0.67						
Tridymite (see Silica-Crystalline)									2019
Triethanolamine	[102-71-6]		5						[2022]
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						
Trimethyl phosphite	[121-45-9]	2	10						
Trimethylamine	[75-50-3]	10	24	15	36				[2022]
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]		0.1					skin	[2022]
Triphenyl amine	[603-34-9]		5						
Triphenyl phosphate	[115-86-6]		3						
Tripoli (see Silica-Crystalline)									2019
Tungsten, as W	[7440-33-7]								

T		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	**[Notes]**	**[Next review]**
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

V		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
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]	50	242	100	483				[2022]
Vinylidene chloride (1,1-Dichloroethylene)	[75-35-4]	5	20	20	79				[2022]

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						

W

		TWA		STEL		CEILING		NOTATIONS	YEAR ADOPTED
Substance	CAS #	ppm	mg/m³	ppm	mg/m³	ppm	mg/m³	[Notes]	[Next review]
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	
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.

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

Regulation 30 of the HSW (GRWM) Regs requires the PCBU to conduct exposure monitoring to determine the concentration of a substance if the PCBU is uncertain on reasonable grounds about whether the concentration exceeds the relevant prescribed exposure standard. As discussed earlier, exposure monitoring and/or biological monitoring may be used to monitor a worker's exposure.

Under most circumstances worker health 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.

For further information about the Code of Health and Disability Services Consumer's Rights see the Health and Disability Commissioner website: www.hdc.org.nz

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.

Regulation 32 of the GRWM Regulations requires the PCBU to ensure the results of exposure monitoring are made available to any person at the workplace who may be, or may have been, exposed to the health hazard. Such results must not contain any information that identifies, or discloses anything about, an individual worker.

Regulation 39 of the GRWM Regulations requires the PCBU to provide the results of health monitoring of a worker to the worker.

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.[13,14]

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*[15]

b. *Industrial Chemical Exposure, Guidelines for Biological Monitoring.*[16]

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.)

[13] 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).

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

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

[16] 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	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
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

EXPOSURE	DETERMINANT	SAMPLING TIME	BEI	NOTE	YEAR ADOPTED
Methyl isobutyl ketone (MIBK)	MIBK in urine	End of shift	0.7mg/litre		2018
Organophosphates (including dichlorvos and malathion)	Cholinesterase activity in blood		**Recommended action**: If less than 60% of Baseline: suspend from working with pesticides 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
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

EXPOSURE	DETERMINANT	SAMPLING TIME	BEI	NOTE	YEAR ADOPTED
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
carcinogen category 1	Known or presumed human carcinogen.
carcinogen category 2	Suspected human carcinogen.
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.
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.
Equivalent aerodynamic 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/m^3	mg = milligrams, and m^3 = cubic metres. mg/m^3 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.

TERM	DEFINITION
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 reaction 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).
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.

TERM	DEFINITION
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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