Workplace Exposure Standard (WES) review

METHYL ACRYLATE
(CAS NO: 96-33-3)

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Te Kāwanatanga o Aotearoa
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WORKSAFE
Mahi Haumaru Aotearoa

CONTENTS

appendices

tables

1.0
Introduction

This WorkSafe New Zealand (WorkSafe) review considers whether the **WES** for methyl acrylate should be changed.

It considers the potential for exposures to methyl acrylate in New Zealand, the health effects and risks, exposure standards from other jurisdictions around the world, and the practicability of measuring exposures.

The review includes a recommendation to change the WorkSafe WES for methyl acrylate, which is currently set at a **WES-TWA** of 10 ppm (35 mg/m^3), with a ***skin*** notation, as published in the special guide *Workplace Exposure Standards and Biological Exposure Indices*, 12th Ed., November 2020 (WorkSafe, 2020).

The WES recommended in this document are guidance values, not prescribed exposure standards. The intention is for them to be used as **risk criteria** for health risk assessment and risk management purposes and to be applied or interpreted only by people with appropriate training and experience. The values proposed in this document are considered by WorkSafe to be health-based WES. This means they are based on minimising health risk and do not take the practicability of achieving or measuring the values into consideration. This also means that in some instances the current analytical or sampling methods will not be sensitive enough to allow measurement at a level sufficiently below the WES to assess risk with a high degree of confidence. In this case there will be some uncertainty as to whether risk is suitably managed. As with any risk assessment, the uncertainties inherent in the assessment need to be considered and minimised so far as is reasonably practicable through good risk assessment and control.

We consider it critical to set health-based values as risk criteria, so that risk assessment is based on an actual understanding of health risk, rather than merely measuring a level of exposure.

Terms that are **bold** (first occurrence only) are further defined in the Glossary.
Synonyms: Methyl propenoate; Methyl-2-propenoate; Methyl prop-2-enoate; Acrylic acid, methyl ester.

2.0 Chemical and physical properties

Methyl acrylate is a clear, colourless, volatile liquid with a persistent acrid odour at room temperature (**ACGIH®**, 2014; **AICIS**, 2014).

Chemical and physical properties of methyl acrylate include:

Formula	$C_4H_6O_2$
Molecular weight	86.09 g/mol
Physical form	Clear, colourless, volatile liquid
Specific gravity	0.9535 g/cm^3 at 20°C
Melting point	-75°C
Boiling point	80.2°C
Relative vapour density	2.97 (air = 1)
Vapour pressure	9.1 kPa at 20°C
Flash point	Closed cup: -3°C
Explosive limits	Lower: 2.8%; Upper: 25% by volume in air
Autoignition temperature	468°C
Solubility	Water: slightly soluble; soluble in alcohol, ether, and other organic solvents
Reactivity	Explosion hazard in vapour form when exposed to heat, sparks, or flame; can react vigorously with oxidising materials; forms peroxides which may initiate exothermic polymerisation
Partition coefficients	logK_{OW} = 0.80 at 20°C
Conversion factors	1 ppm = 3.52 mg/m^3 at 25°C and 760 torr 1 mg/m^3 = 0.28 ppm at 25°C and 760 torr

NLM PubChem, 2020; ACGIH®, 2014

TABLE 1: Physicochemical properties of methyl acrylate

Health-related hazard classifications for methyl acrylate:

SUBSTANCE	CAS NUMBER	CLASSIFICATION
2-Propenoic acid, methyl ester	96-33-3	6.1C (All); 6.1C (O); 6.1C (I); 6.1D (D); 6.3A; 6.4A; 6.5B; 6.9B (All); 6.9B (I)

TABLE 2:
HSNO health-related hazard classifications of 2-propenoic acid, methyl ester (**EPA**, 2020)

For a full listing of all HSNO health-related hazardous substances classification codes and their descriptions, see Appendix 2.

[All] Overall classification for that endpoint.

[O] Oral exposure route.

[D] Derman exposure route.

[I] Inhalation exposure route.

3.0
Uses

Methyl acrylate is primarily used as a co-monomer with acrylonitrile in the production of acrylic and modacrylic fibres (**NLM** PubChem, 2020; ACGIH®, 2014).

Methyl acrylate is also used in the preparation of thermoplastic coatings, adhesives, sealants, amphoteric surfactants for shampoos, medical and dental prostheses, contact lenses, latex coatings, floor and fabric finishes; and, as a resin in the purification of industrial effluents, and in the timed release and disintegration of pesticides (NLM PubChem, 2020; ACGIH®, 2014).

Occupational exposure to methyl acrylate can occur during production, storage, transportation and end-use.

Workers can be exposed to methyl acrylate vapour and liquid via inhalation, and eye and skin contact.

The number of workers exposed or potentially exposed to methyl acrylate in New Zealand workplaces is unknown.

4.0
Health effects

IN THIS SECTION:

4.1 Non-cancer

Humans

The ACGIH® review of methyl acrylate noted:

> "Almost no data are available on the consequences of human exposure to methyl acrylate." (ACGIH®, 2014).

The New Zealand EPA classifies methyl acrylate as a 6.1C and 6.9B substance – a substance that is acutely toxic and a substance that is harmful to human target organs or systems, respectively (EPA, 2020).

The **DFG MAK** review of methyl acrylate summarised the irritation/corrosion potential in exposed humans:

> "An unpublished case-crossover study at the workplace was conducted to determine whether the occupational exposure limit for methyl acrylate of 5 ml/m³ would protect against irritation of the eyes and respiratory tract. A total of 15 employees took part, 10 of whom were production workers, 4 were intermittently exposed workers and 1 was an industrial hygienist who had had no notable previous exposure to methyl acrylate. As each 8-week production cycle was followed by a break of 2 weeks, each participant served as their own control. Irritation was determined by spirometry, peak expiratory flow (**PEF**), ophthalmological examinations and the reporting of symptoms by the participants. The available abstracts do not provide any details about the procedure used to divide the employees into high, middle and low exposure groups. The high exposure group (no details about the number of employees) was exposed to an average methyl acrylate concentration of 2 ml/m³ (7.2 mg/m³). During certain tasks of 2 to 5 minutes in duration, peak exposures of 30 to 126 ml/m³ (107 to 451 mg/m³) were determined. There were no differences in the results of the ophthalmological examinations before and after exposure. Symptoms of irritation in the eyes were of low intensity and even though at the end of the shift the incidence was higher in workers exposed to high concentrations (4.4/100 person days in comparison with 1.4/100 person days in the low concentration group), the increase in incidence was not statistically significant. The examination of lung function parameters revealed no significant changes; a relatively high level of bronchial responsiveness had already been detected in all test persons prior to the start of the production phase (**ECETOC** 1998; **OECD** 2008; **SCOEL** 2004). This study is not suitable for the derivation of a MAK value because of the small number of examined persons, high peak concentrations that are probably responsible for the mild symptoms of irritation in the eyes, and the inadequate description of the exposure conditions and the effects." (References cited in DFG MAK, 2019).

The New Zealand EPA classifies methyl acrylate as a 6.3A and 6.4A substance – a substance that is irritating to the skin and the eye (EPA, 2020).

The DFG MAK review of methyl acrylate summarised the sensitisation potential in humans:

> "There are only a few clinical findings available for methyl acrylate and most of these are incompletely documented. However, it has been established that methyl acrylate has a sensitizing effect on the skin of humans because several cases of sensitization induced by patch tests or through accidental

contact have been described (supplement 'Methyl acrylate' 2001). Methyl acrylate is not commercially available as a test preparation. This is probably the reason why no additional case studies with positive patch test findings have been published since the 1999 supplement (supplement 'Methyl acrylate' 2001) and specifically why there are no clinico-epidemiological studies of affected or possibly exposed collectives. However, a number of studies have been conducted in which specially produced methyl acrylate test preparations were tested in conjunction with sensitization by dimethyl fumarate. Positive reactions were obtained in individual patients with preparations containing 0.06% methyl acrylate and in 1 case with a 0.006% preparation; it is very likely that these were immunological cross-reactions (Giménez-Arnau *et al*. 2009; Lammintausta *et al*. 2010).

"No findings are available for sensitization of the airways." (References cited in DFG MAK, 2019).

The AICIS review of methyl acrylate noted:

"The chemical (at 1% in petrolatum or 20% in olive oil) produced positive results for sensitisation in patch tests in humans. Cross-sensitisation of the chemical with other acrylates and methacrylates has also been reported in humans (OECD, 2003)." (Reference cited in AICIS, 2014).

The New Zealand EPA classifies methyl acrylate as a 6.5B substance – a substance that is a contact sensitiser (EPA, 2020). No studies were located in the cited references regarding reproductive and developmental toxicity of methyl acrylate in humans (DFG MAK, 2019; ACGIH®, 2014; AICIS, 2014; OECD **SIDS**, 2003).

The DFG MAK review of methyl acrylate summarised the genotoxicity potential in humans following exposure:

"In a prospective cohort study, 60 workers employed in the production of acrylic acid, acrylic acid esters and acrylate dispersions and 60 controls were investigated from 1992 to 1999. The average period of exposure was 13 ± 5 years. Exposure to acrylonitrile, *n*-butyl alcohol, *n*-butyl acrylate, ethyl acrylate, methyl acrylate, methyl methacrylate, toluene and styrene was determined by personal passive dosimetry. The measured concentrations of all substances were generally low. In the case of methyl acrylate, 90% of the individual values were below 0.06 ml/m^3, just under 10% were between 0.06 and 0.28 ml/m^3. The maximum concentration was 2.8 ml/m^3. In the clinical, haematological and biochemical examinations, no differences were found between the group of exposed workers and the group of workers not exposed that could be attributed to exposure to the above-listed chemicals. Cytogenetic examination of pairs of peripheral lymphocytes from exposed workers did not reveal genotoxic effects. Throughout the test period, more chromosomal aberrations were observed in exposed persons than in control persons; this difference was statistically significant (Tuček *et al*. 2002; Williams and Iatropoulos 2009). No differentiation was made between smokers and non-smokers and there was exposure to a mixture of substances. For this reason, this study cannot be used as evidence that methyl acrylate has a genotoxic effect." (References cited in DFG MAK, 2019).

Animals

The DFG MAK review of methyl acrylate summarised the acute inhalation toxicity in experimental animals:

> "Exposure of 5 male and 5 female Wistar rats to methyl acrylate concentrations of 10.8 mg/l (10,832 mg/m³; 3,032.96 ml/m³) for 4 hours was lethal for all males and for 2 females. Exposure was nose-only. The symptoms observed in the animals were reduced breathing, diaphragmatic breathing, wheezing, breathing sounds, red, crusty eyes and noses, salivation, sallow skin, piloerection, hyperexcitability, tremor and poor general health. The lungs of 2 of the deceased animals were dark red in colour; in addition, partial lung collapse and hyperexpansion of the lungs with gaseous content was observed in 1 animal. Abnormal gaseous content in the stomach and intestines was found in 4 of the deceased animals. The animals died either directly on the day of exposure or 1 to 2 days later. The **LC_{50}** for the rat was therefore below 3,000 ml/m³ in this study (**BAMM** 2012). Other LC_{50} studies in rats and mice are listed in the REACH dataset that is available to the public. According to this, the values for rats of both sexes are in the range from 3,600 to 6,500 mg/m³ (1,000 to 1,820 ml/m³, respectively) and those for mice are in the range from 5,100 to 5,700 mg/m³ (1,430 to 1,600 ml/m³, respectively) (**ECHA** 2016)." (References cited in DFG MAK, 2019).

The AICIS review of methyl acrylate summarised the acute dermal toxicity in experimental animals:

> "In rabbits (n = 6) exposed to the chemical via occlusive dermal application for 24 hours, an **LD50** of 1,250 **mg/kg bw** was determined (OECD 2003; REACH)." (References cited in AICIS, 2014).

The AICIS review of methyl acrylate summarised the irritation/corrosion potential in experimental animals:

> "In a dermal irritation study (equivalent to OECD **TG** 404), a semi-occlusive dermal application of the chemical (0.5 **ml**, undiluted) was highly irritating to the skin of rabbits. A mean erythema score of 2.17/3 and oedema score of 2.44/4 were reported.
>
> In another study (equivalent to OECD TG 404), rabbits were exposed (n = 2 per treatment time) to the chemical (0.5 ml) via an occlusive dermal application, for four hours or eight days. A mean erythema score of 3.5/4 and a mean oedema score of 3.5/4 were obtained after four hours (OECD, 2003; REACH)."
>
> "The chemical was 'instilled into the eye of one rabbit and caused corneal damage, slight iritis and severe lesions of the conjunctivae. After 7 days the cornea showed moderate to severe opacity' (OECD, 2003). Only limited information is available.
>
> "The chemical was reported to be irritating to the eyes, based on a study conducted with one New Zealand White rabbit (exposed to the undiluted chemical (0.1 ml) and observed for seven days). The following mean scores were documented after 72 hours: cornea 2.33/3, iris 1/1, conjunctival redness 2/2 and chemosis 3/3. The effects were not reversible by day seven, with moderate to severe opacity of the cornea, moderate to severe lesions of the conjunctivae and slight iritis being observed (REACH).

"In another study, the chemical (50**µL**) administered to the eye of Vienna White rabbits (n = 2), resulted in severe swelling and conjunctivitis, and transient corneal opacity after 24 hours. These effects were reversible within three to five days (REACH)."

"In an acute inhalation toxicity study (equivalent to OECD TG 403), SD rats exposed to the chemical up to 9.8**mg/L** for four hours showed strong irritation to the respiratory tract (OECD, 2003) (see Acute toxicity: inhalation). Dose dependent local effects in the respiratory tract of SD rats have been observed in a repeated dose inhalation toxicity study at doses in the range of 5–45 ppm (see Repeat dose toxicity: Inhalation)." (References cited in AICIS, 2014).

The AICIS review of methyl acrylate summarised the sensitisation potential in experimental animals:

"The skin sensitising potential of the chemical was studied in a local lymph node assay (**LLNA**) (OECD TG 429) using female CBA mice (n = 4/dose) at concentrations of 1.0, 2.5, 5.0, 10 and 20% of the chemical (in acetone/olive oil at 4:1 v/v). The chemical was determined to be a weak skin sensitiser based on the effective concentration needed to produce a three-fold increase in lymphocyte proliferation (**EC3**) of 19.6% (Dearman *et al*., 2007; REACH).

"The chemical also gave positive skin sensitisation results in several studies including split adjuvant, Polak, modified Draize and modified maximisation tests in guinea pigs (REACH)." (References cited in AICIS, 2014).

The AICIS review of methyl acrylate summarised the repeat dose toxicity in experimental animals:

"In a 12-week repeated dose inhalation study (OECD TG 413), SD rats (n = 10/sex/dose) were exposed to vapours of the chemical at concentrations of 0, 23, 124, 242 or 626 ppm (0, 0.082, 0.44, 0.86 or 2.24 mg/L) for six hours a day, five days a week. At the highest dose, the animals showed laboured breathing, irritation of the mucosa and haemorrhagic discharge from the eyes and nose. All animals in the highest dose group died during the study due to strong irritation effects in the respiratory system. The no observed effect concentration (**NOEC**) for local effects was 23 ppm (0.082 mg/L). Absolute organ weights (heart, liver, kidney and spleen) were decreased in males at 242 ppm. Absolute spleen weight was also reduced in males at 124 ppm (OECD, 2003).

"A two-year inhalation study exposed SD rats to the chemical (> 99.8% purity) for six hours a day, five days a week at 0, 5, 15 and 45 ppm (equivalent to 0, 0.019, 0.058 and 0.173 mg/L) for the first 13 weeks, and then at 0, 15, 45 and 135 ppm (0, 0.058, 0.173 and 0.519 mg/L) until the end of the study. Dose-dependent local effects were observed (attributed to the irritant effects of the chemical). There were no systemic toxicity effects detectible by haematological and histopathological examinations (OECD, 2008)." (References cited in AICIS, 2014).

The DFG MAK review of methyl acrylate summarised the reproductive toxicity in experimental animals:

> "In a 2-generation study carried out in compliance with OECD Test Guideline 416, 27 Sprague Dawley rats per sex and group were exposed by inhalation to methyl acrylate concentrations of 0, 5, 25 and 75 ml/m³ in whole-animal exposure chambers for 6 hours a day, on 7 days a week, beginning 10 weeks before mating and lasting until the end of lactation. The only exception were the dams; they were not exposed to the substance from gestation day 20 to lactation day 4. At the end of lactation, the **F1** parent animals were selected from among the offspring and then exposed to methyl acrylate using the same procedure as for the **F0** generation, beginning in postnatal week 4 and lasting until weaning of the **F2** generation. No treatment-related fatalities, clinical signs, or pathological or histological changes in the reproductive organs of the F0 or F1 generations were observed. Sperm parameters and the oestrus cycle remained unchanged. Body weight gains, feed consumption and the terminal body weights of the male and female F0 and F1 parent animals of the high concentration group were reduced in comparison with the controls. However, although the terminal body weights were reduced in the male F0 parent animals, the decrease was not statistically significant. The relative testis and epididymis weights of the male F0 animals and the relative liver and brain weights of the female F0 animals were increased in comparison with the controls. In the F1 generation, the relative weights of the brain, testes, seminal vesicles with coagulating glands and the epididymis in the males and the relative weights of the adrenal gland and brain tissues of parent animals of the F0 and F1 generations at concentrations of 25 ml/m³ and above; the increase in the incidence and severity of these effects was dependent on the concentration. An exact description of these effects can be found in the Section 'Subacute, subchronic and chronic toxicity'. The following parameters remained unchanged by the treatment: mating, conception, fertility, gestation indices, post-implantation losses, the onset of mating, the length of gestation, litter size, the sex ratio and postnatal survival indices. The time of vaginal opening and preputial separation in the offspring was similar to that in the controls (see Table 4; Acrylate REACH Task Force 2009).
>
> "The **NOAEC** for local toxicity in the parent animals of the F0 and F1 generations was determined to be 5 ml/m³ on the basis of histopathological effects in the nasal tissues. The NOAEC for systemic effects in the parent animals and offspring was 25 ml/m³ on the basis of reduced body weights. The NOAEC for fertility was 75 ml/m³, the highest concentration tested." (References cited in DFG MAK, 2019).

The DFG MAK review of methyl acrylate summarised the developmental toxicity in experimental animals:

> "Groups of 25 pregnant Sprague Dawley rats (controls: 27) were exposed daily to methyl acrylate concentrations of 0, 25, 50 and 100 ml/m³ for 6 hours a day, from gestation days 6 to 20. Maternal feed consumption and body weight gains were decreased after exposure to the medium concentration and above; after the uterus weights were subtracted, the dams were found to even have lost body weight. A concentration-dependent decrease in foetal body weights was likewise observed; this decrease was statistically significant in the high concentration group. A malformation (craniorhachischisis) was found in 1 foetus of the 100 ml/m³ group; this malformation was not considered to have been caused by the substance.

There was no incidence of skeletal variations induced by the substance. In this study, the NOAEC for maternal toxicity was 25 ml/m³, the NOAEC for developmental toxicity was 50 ml/m³ (Saillenfait *et al*. 1999).

"Groups of 25 pregnant Himalayan rabbits were exposed daily to methyl acrylate concentrations of 0, 5, 15 and 45 ml/m³ for 6 hours a day from gestation day 6 to 28. Foetuses were examined on gestation day 29. No effects on developmental toxicity parameters or on the foetuses were observed up to the high concentration. Degeneration and atrophy of the olfactory epithelium (plane of section III: 0/25, 0/25, 4/25, 25/25; plane of section IV: 0/25, 0/25, 0/25, 21/25) were detected in the dams at the medium concentration of 15 ml/m³ and above. The NOAEC for systemic maternal toxicity was 15 ml/m³ because the damage to the nasal epithelium was so severe at concentrations of 45 ml/m³ that this probably induced stress in the dams. The NOAEC for developmental toxicity was 45 ml/m³, the highest concentration tested (Acrylate Task Force 2010)." (References cited in DFG MAK, 2019).

The AICIS review of methyl acrylate summarised genotoxic potential in experimental animals and *in vitro* test systems:

"Based on the results of available *in vitro* and *in vivo* genotoxicity studies, the chemical is not considered to be genotoxic.

"The chemical gave mixed results for *in vitro* genotoxicity testing:

- negative results were observed in several *in vitro* bacterial reverse mutation assays (Ames test) with *Salmonella typhimurium* (strains TA 98, 100, 1535, 1537 and 1538), with or without metabolic activation (OECD, 2008);
- positive results were observed in mammalian chromosome aberration assays using Chinese hamster fibroblast, lung or ovary cells as well as mouse lymphoma (L5178Y) cells (OECD, 2008); and
- two gene mutation assays using mouse lymphoma (L5178Y) cells, gave positive results without metabolic activation (OECD, 2008; REACH).

"The chemical gave mixed results for genotoxicity in the following *in vivo* assays:

- male ddY mice (n = 2/dose) exposed to vapours of the chemical at 1,300 or 2,100 ppm (4.64 or 7.50 mg/L) for three hours showed no chromosome aberrations in bone marrow samples taken at 18, 24, 30, 48 and 72 hours following exposure (OECD, 2008);
- no chromosome aberrations were observed in male ddY mice exposed to a single oral gavage dose of the chemical at 62.5, 125 or 250 mg/kg bw (n = 6/dose) or a repeated oral dose of 125 mg/kg bw for four days (n = 4) (OECD, 2008; REACH);
- male Balb/C mice exposed to the chemical at 37.5, 75, 150 or 300 mg/kg bw (n = 4/dose) via intraperitoneal injection showed increased micronuclei at toxic dose levels. However, this study was poorly described and the results were reported to be questionable, as other laboratories could not replicate this positive result (OECD, 2008); and
- a gene mutation test on Drosophila melanogaster produced negative results for the chemical at 500ppm."

(References cited in AICIS, 2014).

4.2 Cancer

The International Agency for Research on Cancer [**IARC**] evaluation of methyl acrylate concluded that:

> No epidemiological data relevant to the carcinogenicity of methyl acrylate were available.
>
> There is *inadequate evidence* in experimental animals for the carcinogenicity of methyl acrylate.
>
> With an overall evaluation that:
>
> Methyl acrylate is *not classifiable as to its carcinogenicity to humans (Group 3)* (IARC, 1999).

The US National Toxicology Program [**NTP**] Report on Carcinogens [**RoC**], Fourteenth Edition has no evaluation on the carcinogenic potential of methyl acrylate (NTP RoC, 2016).

The New Zealand EPA has not classified methyl acrylate as a 6.7A or 6.7B substance – substances that are respectively known or presumed, or suspected human carcinogens (EPA, 2020).

Humans

No studies were located in the cited references regarding exposure and carcinogenicity potential of methyl acrylate in humans (DFG MAK, 2019; ACGIH®, 2014; AICIS, 2014; OECD SIDS, 2003).

Animals

The AICIS review of methyl acrylate summarised the data on exposure and carcinogenicity in experimental animals:

> "In a two-year combined repeated dose and carcinogenicity study (OECD TG 453), SD rats (n = 86/sex/dose) were exposed (via inhalation) to the chemical for six hours a day, five days a week at concentrations of 0, 5, 15, 45 or 135 ppm (0, 0.019, 0.058, 0.173 or 0.519 mg/L). No significant neoplastic changes were observed (OECD, 2008).
>
> "The main hydrolysis products, acrylic acid and methanol, were also not considered carcinogenic (NICNASa; NICNASb)." (References cited in AICIS, 2014).

4.3 Absorption, distribution, metabolism and excretion

The DFG MAK review of methyl acrylate summarised the absorption, distribution, metabolism and excretion (**ADME**):

> "Methyl acrylate is readily absorbed after oral, dermal and inhalation exposure and distributed throughout the body (OECD 2008). Two hours after oral doses of ^{14}C-labelled methyl acrylate were given to rats, most of the radioactivity was detected in the liver, kidneys, plasma and erythrocytes (Sapota 1993). Using the models of Fiserova-Bergerova *et al*. (1990), Guy and Potts (1993) and Wilschut *et al*. (1995), flux values were calculated for a saturated aqueous solution that correspond with absorbed amounts of 1,670 mg, 195 mg and 315 mg, respectively, assuming 1-hour exposure of 2,000 **cm²** of skin.

> "The metabolic pathway of methyl acrylate is hydrolysis by carboxyesterases to form acrylic acid and methanol (OECD 2008).
>
> "After oral or intraperitoneal administration, more than 90% of the methyl acrylate was eliminated within 72 hours, primarily via the lungs as carbon dioxide (> 50%) and via the kidneys (40%–50%) as products of glutathione conjugation (OECD 2008)." (References cited in DFG MAK, 2019).

The DFG MAK review of methyl acrylate summarised the mode of action for the observed effects:

> "*In vitro* studies have demonstrated that the hydrolysis of acrylate esters and the formation of acrylic acid associated with this is a detoxification mechanism. There were no significant differences between methyl acrylate, ethyl acrylate and *n*-butyl acrylate with regard to hydrolysis rates and their reaction with nucleophiles (Miller *et al*. 1985; Roos 2015).
>
> "Decisive for the toxicity of acrylates and methyl acrylates is not the release of the acid but the reactivity of the Michael system (α,β-unsaturated compounds) with nucleophilic compounds such as glutathione (McCarthy and Witz 1997; McCarthy *et al*. 1994). *In vitro*, sulfhydryl groups that are not bound to proteins are depleted." (References cited in DFG MAK, 2019).

5.0 Exposure standards

IN THIS SECTION:

5.1 Other exposure standards

Table 3 below shows methyl acrylate exposure standards from around the world, as published by the Institute for Occupational Safety and Health of the German Social Accident Insurance (**IFA**, 2020).

JURISDICTION OR ADVISORY BODY	8-HOUR LIMIT VALUE		SHORT-TERM LIMIT VALUE	
	ppm	mg/m³	ppm	mg/m³
Australia	10	35		
Austria	5	18	10[1]	36[1]
Belgium[2]	2	7.2	10[1]	36[1]
Canada – Ontario	2			
Canada – Québec	2	7		
Denmark	2	7	4	14
European Union[3]	5	18	10[1]	36[1]
Finland	2	7	5[1]	18[1]
France[4]	5	18	10	36
Germany – AGS	2	7.1	4[1]	14.2[1]
Germany – DFG	2	7.1	4[1]	14.2[1]
Hungary		18		36[1]
Ireland	5	18	10[5]	36[5]
Italy[6]	2	7	10[1]	36[1]
Japan – JSOH	2	7		
Latvia	5	18	10[1]	36[1]
New Zealand	10	35		
People's Republic of China		20		
Poland		14		28
Romania	5	18	10[1]	36[1]
Singapore	10	35		
South Korea	2	7		
Spain[6,7]	2	7.2		
Sweden	5	18	10[1]	36[1]
Switzerland	5	18	10[1]	36[1]
The Netherlands		18		36
Turkey	5	18	10[1]	36[1]
USA – NIOSH	10	35		
USA – OSHA	10	35		
UK	5	18	10[1]	36[1]

TABLE 3: Exposure standards for methyl acrylate from around the world

[1] 15 minutes average value.

[2] Additional indication "D" means that the absorption of the agent through the skin, mucous membranes or eyes is an important part of the total exposure. It can be the result of both direct contact and its presence in the air.

[3] Indicative Occupational Exposure Limit Value (**IOELV**).

[4] Indicative statutory limit values.

[5] 15 minutes reference period.

[6] **Skin** notation.

[7] **sen** notation.

It is noted that the only organisations from whom we obtained information as to how and why they set occupational exposures standards on methyl acrylate were DFG, Safe Work Australia and ACGIH®.

5.2 DFG

The Deutsche Forschungsgemeinschaft [DFG, German Research Foundation] re-evaluation of methyl acrylate recommended a MAK value of 2 ml/m³ (7.1 mg/m³), **Peak Limitation Category I** (excursion factor 2), with **"H"**, **"Sh"** and **Pregnancy Risk Group C** notations (DFG MAK, 2019).

Rationale:

"The critical effects of exposure to methyl acrylate are reserve cell hyperplasia with the loss of cilia and olfactory cells, degeneration with regeneration of the olfactory epithelium, hyperplasia of the transitional epithelium, and hyperplasia and hypertrophy of the goblet cells in the respiratory epithelium of rats.

MAK VALUE

"No data have been reported for sensory irritation in humans that would be relevant to the evaluation. A workplace study with 15 test persons exposed to methyl acrylate is not suitable for the derivation of a MAK value because of the small number of persons investigated, the high peak concentrations that were probably responsible for the irritation caused by the substance and an insufficient description of the exposure conditions and effects. The original report of this study is not available. The derivation of the MAK value is therefore based on the findings from animal studies.

"A NOAEC of 5 ml/m³ was determined in a 2-generation study with daily exposure of Sprague Dawley rats, the males for a total of about 12 weeks and the females for about 4.5 months. In the group exposed to the next-higher concentration of 25 ml/m³, multifocal hyperplasia of the transitional epithelium and hyperplasia and hypertrophy of the goblet cells in the respiratory epithelium were reported in the parent animals of both generations. Also, degeneration with regeneration of the olfactory epithelium was observed. Effects on the transitional epithelium between the olfactory and respiratory epithelium were found in exposed rats in the 2-year inhalation study with a **LOAEC** of 15 ml/m³. A **$BMDL_{05}$** of 6.8 ml/m³ was calculated from this study for male rats. On the basis of the overall data provided by the two studies and taking into consideration the daily exposure of the rats in the 2-generation study, the MAK value is derived from the BMDL05 of 6.8 ml/m³ from the 2-year study. Using the approach of Brüning *et al*. (2014) for the extrapolation of the effects on the olfactory and respiratory epithelium of rats to humans (1:3) and the application of the preferred value approach, a MAK value of 2 ml/m³ is derived.

"The findings are consistent with those of the 2-year study with n-*butyl acrylate* (BASF 1984; BASF AG 1985 b; Reininghaus *et al*. 1991). In the case of *ethyl acrylate* primarily effects on the olfactory epithelium of F344 rats were observed at concentrations of 25 ml/m³ in a 27-month study. No effects were recorded in a 2-year study that tested only the one concentration of 5 ml/m³ (Miller *et al*. 1985).

"The hydrolysis of the acrylates investigated is a detoxification mechanism. For this reason, the reaction with nucleophiles and not the release of the acid is decisive for the toxicity of these acrylates. *In vitro* studies of the reaction with nucleophiles found that methyl acrylate, ethyl acrylate and *n*-butyl acrylate have similar levels of reactivity, which supports the MAK value of 2 ml/m³ that has been established for these substances. This is further supported by the NOAEC of 2 ml/m³ for sensory irritation determined in a study with exposure of test persons to ethyl acrylate (supplement 'Ethyl acrylate' 2016).

"Adverse effects caused by the metabolite methanol, which has a MAK value of 200 ml/m³, are not to be expected at the level of the MAK value established for methyl acrylate.

PEAK LIMITATION

"The substance remains classified in Peak Limitation Category I; this classification was made on the basis of local effects. *In vitro* studies of the reaction with nucleophiles found that ethyl acrylate and methyl acrylate have similar levels of reactivity. For this reason, an excursion factor of 2 has been established for methyl acrylate in analogy to that for ethyl acrylate because no studies in test persons are available for methyl acrylate. In a valid study in test persons, no irritation of the eyes and nose could be detected after 4-hour exposure to ethyl acrylate concentrations averaging 2.5 ml/m³ and peak concentrations of twice that value (supplement 'Ethyl acrylate' 2016).

PRENATAL TOXICITY

"In a study of the toxic effects on prenatal development carried out in rats and rabbits according to OECD Test Guideline 414, reduced foetal weights were observed concurrently with maternal toxicity after the exposure of rats to methyl acrylate concentrations of 100 ml/m³. In rabbits, the NOAEC for developmental toxicity was 45 ml/m³, the highest concentration tested. At this concentration, histopathological damage to the olfactory epithelium was observed in all dams. In a 2-generation study with Sprague Dawley rats, the LOAEC for developmental toxicity was determined to be 75 ml/m³ on the basis of the reduced weight of the offspring. After inhalation exposure, the NOAEC for toxic effects on prenatal development was 50 ml/m³ in rats, 45 ml/m³ in rabbits and 25 ml/m³ in a 2-generation study in rats. As the 25-fold, 23-fold and 13-fold margins between these values and the MAK value of 2 ml/m³ (7.1 mg/m³) are sufficiently large, methyl acrylate has been classified in Pregnancy Risk Group C.

CARCINOGENICITY

"No other data have become available for the carcinogenic effects of methyl acrylate since the documentation of 1986 was published (documentation 'Methyl acrylate' 1993). No carcinogenic effects were observed in the 2-year inhalation study in rats. Methyl acrylate has therefore not been classified in any of the categories for carcinogenic substances.

GERM CELL MUTAGENICITY

"No data for germ cells are available. Methyl acrylate did not induce gene or point mutations in bacteria and mammalian cells. Methyl acrylate had a clastogenic effect *in vitro*. These positive results were not confirmed *in vivo*. Overall, methyl acrylate is not assumed to be a germ cell mutagen. Methyl acrylate has therefore not been classified in any of the categories for germ cell mutagens.

ABSORPTION THROUGH THE SKIN

"Model calculations (see Section 'Toxicokinetics and Metabolism') yielded dermal absorption values of up to 1,670 mg in humans after exposure to a saturated aqueous solution and assuming 1-hour exposure of 2000 cm² of skin. On the basis of the systemic NOAEC of 135 ml/m³ (482 mg/m³) from the 2-year study in rats (documentation 'Methyl acrylate' 1993), a respiratory volume of 10 **m³** at the workplace and after extrapolation of this value to the human (1/2) taking into consideration the higher respiratory volume at the workplace in comparison with exposure of animals at rest (1/2), this results

in a systemically tolerable amount of about 1,205 mg. As the absorption of methyl acrylate through the skin is thus higher than 25% of the systemically tolerable amount, the substance is designated with an 'H' (for substances which can be absorbed through the skin in toxicologically relevant amounts).

SENSITIZATION

"The only data available for the contact-sensitizing effects of methyl acrylate are the case reports that were included in the supplement from 1999 (supplement 'Methyl acrylate' 2001). However, the positive result in a local lymph node assay confirms that the substance has skin-sensitizing potential. Data for the sensitization of the respiratory passages are not available. Methyl acrylate is therefore designated with 'Sh' but not with 'Sa' (for substances which cause sensitization of the skin or airways)." (References cited in DFG MAK, 2019).

5.3 ACGIH®

The ACGIH® review of methyl acrylate concluded with recommendations that a **TLV-TWA** of 2 ppm (7mg/m^3) for occupational exposure to methyl acrylate, would minimise the potential for acute and chronic irritation of the eyes, skin, and mucous membranes reported for workers exposed at 12-hour TWA personal sampling concentrations averaging 2 ppm, and mean area samples of 5.4 ppm (ACGIH®, 2014).

Rationale:

"In comparison with other acrylates, methyl acrylate is the most acutely toxic congener by oral, topical, and inhalation exposure in animals (Murphy and Davies, 1993; Autian, 1975; Oberly and Tansy, 1985). It is a moderate skin and mucous membrane irritant, and it is a skin sensitizer in animals. In lifetime inhalation studies (Reininghaus *et al*., 1991), the **NOEL** in rats was less than 15 ppm (as compared with less than 135 ppm for butyl acetate). The effects seen at 15 ppm included reversible irritation of the nasal mucosa and opacity and neovascularization of the cornea. No published human data are available other than experimental skin testing, which revealed that methyl acrylate is a skin sensitizer and a moderate irritant, and a short-term case-crossover study at levels at or below 2 to 5 ppm TWA, in which some participants reported eye irritation that increased in those with higher exposures and increased bronchial reactivity in a previously unexposed worker after exposure (Cavelier *et al*., 1981; Milton *et al*., 1996).

"A TLV-TWA of 2 ppm is recommended, based on the results from the acute human study (Milton *et al*., 1996) and the rodent chronic toxicity bioassay (Reininghaus *et al*., 1991) to minimize the potential for acute and chronic irritative effects of methyl acrylate on the cornea, skin, and mucous membranes. An **A4**, **Not Classifiable as a Human Carcinogen**, carcinogenicity notation is recommended as a consequence of the rodent bioassay (Bull *et al*., 1987; Rohm & Haas Co., 1985) in which benign hypophyseal tumors and epithelial and leukemic neoplasms were identified but were without dose-response relationships. The Skin notation is also recommended (despite its acute irritant properties) due to significant, acute percutaneous absorption of the compound found in animal studies (Seutter and Rijntjes, 1981). Available data in animals (Potokar *et al*., 1985; Parker and Turk, 1983; Turk *et al*., 1986; Parker *et al*., 1985; Bull *et al*., 1987) and humans (Cavelier *et al*., 1981) from exposure to methyl acrylate warrant the addition of the **DSEN** notation.

The recommended **TLV** may not necessarily protect susceptible workers from possible sensitization or an allergic reaction in previously sensitized individuals; accordingly, exposures should be kept as low as possible below the recommended TLV.

"Sufficient data were not available to recommend an **RSEN** notation or a **TLV-STEL**." (References cited in ACGIH®, 2014).

5.4 Safe Work Australia

In their draft proposal, Safe Work Australia has recommended an 8-hour TWA of 2 ppm (7mg/m^3) for methyl acrylate to protect for irritation to the eyes, skin and respiratory system in exposed workers.

"The critical effects of exposure are irritation to the eyes, skin and respiratory system. While limited human data are available, experimental data indicate it is a moderate irritant. Increased irritation of the eyes associated with increasing concentrations above an average of 2 ppm reported in ten workers over a 12-hour shift." (Safe Work Australia, 2019)

6.0 Analytical methods for the assessment of airborne methyl acrylate

A common method to measure methyl acrylate exposure is using NIOSH Method 1459 Issue 1 (NIOSH, 1994).

Using this method an air sample of 1 to 5 litres is collected onto a solid sorbent tube (coconut shell charcoal), using a flow rate of 0.01 to 0.2 litres per minute. Following desorption of the analyte using carbon disulphide, the sample is analysed using gas chromatography/flame ionisation detection.

With an air volume of 0.01 litres per minute, sample time of 8 hours and detection limit of 10µg the method could measure to 2.083 mg/m^3 or 0.59 ppm.

It is acknowledged that this method is not sufficiently sensitive to reliably determine airborne concentrations of methyl acrylate at or around the proposed WES-TWA or WES-STEL.

Methyl acrylate concentrations may be determined using passive diffusion monitors; however, the detection limit of the proposed analytical method should be confirmed with the laboratory.

Methyl acrylate concentrations may also be determined using a direct-reading instrument fitted with a photoionisation detector.

7.0
Discussion

WorkSafe's WES for methyl acrylate has been unchanged since adoption in 1994.

The toxicological database reviewed above indicates that methyl acrylate is locally toxic to humans, causing eye, skin and respiratory tract irritation and dermal sensitisation. Methyl acrylate is locally toxic to experimental animals, causing eye, skin and respiratory tract irritation and dermal sensitisation.

Based on the aforementioned documentation, informed by the conclusions of the DFG and ACGIH® reviews, and in particular the findings listed below, WorkSafe considers its current WES-TWA of 10 ppm (35 mg/m^3) for methyl acrylate, to be inadequate to manage health risks from possible workplace exposure:

- The DFG re-evaluation of methyl acrylate recommended a MAK Value of 2 ml/m^3 (7.1 mg/m^3), Peak Limitation Category I (excursion factor 2), with "H", "Sh" and Pregnancy Risk Group C notations (DFG MAK, 2019). The MAK Value was based on a BMDL05 of 6.8 ml/m^3 from a 2-year inhalation study in rats (DFG MAK, 2019).
- The ACGIH® review of methyl acrylate concluded with recommendations that a TLV-TWA of 2 ppm (7 mg/m^3) for occupational exposure to methyl acrylate, would minimise the potential for acute and chronic irritation of the eyes, skin, and mucous membranes reported for workers exposed at 12-hour TWA personal sampling concentrations averaging 2 ppm, and mean area samples of 5.4 ppm (ACGIH®, 2014).
- The Safe Work Australia draft review of methyl acrylate recommended a TWA of 2 ppm (7 mg/m^3) with Sk. and DSEN notations, to protect for irritation of the eyes and skin, and respiratory system in exposed workers (SafeWork, 2019). The recommended TWA was based on increased irritation of the eyes associated with increasing concentrations above an average of 2 ppm reported in ten workers over a 12-hour shift; and the NOAEC/LOAEC of 15 ppm reported in two-year rat inhalation studies for effects on the cornea, and olfactory and respiratory epithelium ($BMDL_{05}$ of 6.8 ppm; DFG, 2016 cited in SafeWork, 2019).
- The proposed WES-TWA of 2 ppm (7.1 mg/m^3) for methyl acrylate is intended to protect exposed workers from eye, skin and respiratory tract irritation (DFG MAK, 2019; ACGIH®, 2014).
- The proposed **WES-STEL** of 4 ppm (14.2 mg/m^3) for methyl acrylate is intended to protect exposed workers from potential peak concentrations initiating irritation reactions (DFG MAK, 2019).
- A skin notation is justified for methyl acrylate, due to estimates of the potential significance of dermal absorption (DFG MAK, 2019; ACGIH®, 2014). Although, the irritant nature of methyl acrylate is likely to limit dermal contact.
- Available information indicates that methyl acrylate is a skin sensitiser (DFG MAK, 2019; ACGIH®, 2014) without adequate evidence for respiratory sensitisation, so a ***sen*** notation is not warranted.
- Allergic sensitisation is considered an irreversible change (OECD, 2012), and while threshold levels exist for allergic sensitisation by allergenic substances (OECD, 2012), the data for methyl acrylate from human experience or animal studies was inadequate to quantitatively derive such a threshold (ACGIH®, 2014).

8.0 Recommendations

WorkSafe considers its current WES-TWA of 10 ppm (35 mg/m^3) for methyl acrylate to be inadequate to protect workers exposed in the workplace, based on current knowledge.

It is proposed that WorkSafe:

1. adopt a WES-TWA for methyl acrylate of 2 ppm (7.1 mg/m^3)
2. adopt a WES-STEL for methyl acrylate of 4 ppm (14.2 mg/m^3)
3. maintain a *skin* notation for methyl acrylate.

Noting that the proposed WES-TWA and WES-STEL for methyl acrylate may not eliminate all risk, due to the potential contribution of dermal exposures to total body burden, and the potential for skin sensitisation or for triggering reactions in pre-sensitised individuals, so workplace exposures should be minimised.

Appendices

IN THIS SECTION:

Appendix 1: Glossary

TERM	MEANING
A4 Not Classifiable as a Human Carcinogen	Agents which cause concern that they could be carcinogenic for humans but which cannot be assessed conclusively because of lack of data. *In vitro* or animal studies do not provide indications of carcinogenicity which are sufficient to classify the agent into one of the other categories. An ACGIH® term.
ACGIH®	The American Conference of Governmental Industrial Hygienists (ACGIH®) is a member-based organisation, established in 1938, that advances occupational and environmental health. Examples of this include their annual edition of the TLVs® and BEIs® book and work practice guides. Store at: https://portal.acgih.org/s/store#
ADME	Absorption, Distribution, Metabolism and Excretion.
AGS	Ausschuss für Gefahrstoffe [Committee for Hazardous Substances] is a consultative body of the German Federal Ministry of Labour and Social Affairs on issues of the Ordinance on Hazardous Substances. Administered by the BAuA.
AICIS	Australian Industrial Chemicals Introduction Scheme – the regulatory scheme that administers the Australian law regulating the importation and manufacture of industrial chemicals in Australia. AICIS replaced the National Industrial Chemicals Notification and Assessment Scheme (**NICNAS**) on 1 July 2020.
BAMM	Basic Acrylate Monomer Manufacturers.
BAT	Biologische Arbeitsstoff-Toleranzwerte [Biological Tolerance Value], a DFG term.
BMDL05	Benchmark dose, 95% lower confidence limit.
bw or b.w.	Body weight.
cm^2	Square centimetre of area.
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation), the Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area, Federal Republic of Germany. The science-based MAK values are recommended to the German Minister of Labour and Social Affairs for possible adoption under the German Hazardous Substances Ordinance.
DSEN	A notation indicating the substance is a dermal sensitiser. DSEN is used in place of SEN when specific evidence of sensitisation by the dermal route is confirmed by human or animal data. An ACGIH® term.
EC3 or EC_3	The amount of a substance that is required to elicit a stimulation index of 3 [in a Mouse/Murine Local Lymph Node Assay].
ECETOC	European Centre for Ecotoxicology and Toxicology of Chemicals [formally: European Chemical Industry Ecology and Toxicology Centre].
ECHA	The European Chemicals Agency (an agency of the European Union).
EPA	The New Zealand Environmental Protection Authority.
F0	Parents to first filial generation, F1.
F1	First filial generation.
F2	Second filial generation.
"H"	DFG MAK designation: *danger of percutaneous absorption*. Equivalent to the skin notation in the WorkSafe WES special guide.
HSNO	Hazardous Substances and New Organisms Act 1996, New Zealand.
IARC	The International Agency for Research on Cancer – an agency of the World Health Organisation.
IFA	Institut für Arbeitsschutz der Deutschen Gestzlichen Unfallversicherung [Institute for Occupational Safety and Health of the German Social Accident Insurance].
IOELV	Indicative Occupational Exposure Limit Value (health-based, SCOEL parameter).
LC_{50}	Lethal Concentration for 50% of the test population.

TERM	MEANING
LD_{50}	Lethal Dose for 50% of the test population.
LLNA	Local lymph node assay.
LOAEC	Lowest Observed Adverse Effect Concentration.
m^3	Cubic metre.
MAK	Maximale Arbeitsplatz-Konzentration, (maximum workplace concentration) is defined as the maximum concentration of a chemical substance (as gas, vapour or particulate matter) in the workplace air which generally does not have known adverse effects on the health of the employee nor cause unreasonable annoyance (for example, by a nauseous odour) even when the person is repeatedly exposed during long periods, usually for 8 hours daily but assuming on average a 40-hour working week. Values set by the DFG.
µL or µl	Microlitre or one millionth of a litre.
mg	Milligram or one thousandth of a gram.
mg/kg	Milligrams per kilogram.
mg/kg b.w. or mg/kg bw	Milligram of substance per kilogram body weight.
mg/L or mg/l	Milligram of substance per litre.
mg/m^3	Milligrams of substance per cubic metre of air.
mL or ml	Millilitre or one thousandth of a litre.
mL/m^3 or ml/m^3	Millilitres of substance per cubic metre (of air).
NICNAS	National Industrial Chemicals Notification and Assessment Scheme is – the Australian government's regulatory body for industrial chemicals.
NIOSH	The National Institute for Occupational Safety and Health is the United States federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness.
NLM	National Library of Medicine, administered by the US National Institutes of Health.
NOAEC	No Observed Adverse Effect Concentration.
NOAEL	No Observed Adverse Effect Level.
NOEC	No Observed Effect Concentration.
NOEL	No Observed Effect Level
NTP	National Toxicology Program, US Department of Health and Human Services.
OECD	Organisation for Economic Co-operation and Development.
Peak limitation category 1	Substances for which local irritant effects determine the MAK Value, also respiratory allergens; Excursion factor = 1 [default]; Duration 15 minutes, average value; Number per shift = 4; Interval = 1 hour. A DFG term.
PEF	Peak Expiratory Flow.
ppm	Parts of vapour or gas per million parts of air.
Pregnancy Risk Group C	Damage to the embryo or foetus is unlikely when the MAK Value or the BAT value is observed. A DFG term.
Risk criteria	The terms of reference against which the significance of risk is evaluated. It is used to support decision making on health risk management. ISO 31000 2nd edition *Risk Management – guidelines* (2018).
RoC/ROC	Report on Carcinogens.

TERM	MEANING
RSEN	A notation indicating the substance is a respiratory sensitiser. RSEN is used in place of SEN when specific evidence of sensitisation by the inhalation route is confirmed by human or animal data. An ACGIH® term.
SCOEL	The Scientific Committee on Occupational Exposure Limits is a committee of the European Commission, established in 1995 to advise on occupational health limits for chemicals in the workplace within the framework of Directive 98/24/EC, the chemical agents directive, and Directive 90/394/EEC, the carcinogens at work directive.
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. A WorkSafe term.
SEN	A notation indicating the substance is a sensitiser. DSEN and RSEN are used in place of SEN when specific evidence of sensitisation by the dermal or respiratory route, respectively, is confirmed by human or animal data. An ACGIH® term.
"Sh"	DFG MAK designation: *danger of sensitisation of the skin*.
skin	Skin absorption – applicable to a substance that is capable of being significantly absorbed into the body through contact with the skin. A WorkSafe term.
Skin	A notation indicating the potential for significant contribution to the overall exposure, by the cutaneous route, including mucous membranes and the eyes, by contact with vapours, liquids and solids. An ACGIH® term.
STEL (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. A WorkSafe term.
TG	Test Guideline. An OECD term.
TLV®	Threshold Limit Value (see TLV-STEL and TLV-TWA below). An ACGIH® term. Please see the Statement of Position Regarding the TLVs® and BEIs® and Policy Statement on the Uses of TLVs® and BEIs®
TLV-STEL	TLV-Short-Term Exposure Limit; a 15-minute TWA exposure that should not be exceeded at any time during a workday, even if the 8-hour TWA is within the TLV-TWA. An ACGIH® term.
TLV-TWA	TLV – Time-Weighted Average; the TWA concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed to, day after day, for a working lifetime without adverse effect. An ACGIH® term.
WES	Workplace Exposure Standard – WESs 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 week. A WorkSafe term.
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. A WorkSafe term.
WES-TWA	The average airborne concentration of a substance calculated over an eight-hour working day. A WorkSafe term.

Appendix 2: HSNO health-related hazardous substance classifications

This is the full list of all health-related hazardous substances classifications that are listed by the NZ EPA, including those that apply to this substance.

CLASSIFICATION CODE	MEANING
Acutely toxic	
6.1A	Substances that are acutely toxic – Fatal
6.1B	Substances that are acutely toxic – Fatal
6.1C	Substances that are acutely toxic – Toxic
6.1D	Substances that are acutely toxic – Harmful
6.1E	Substances that are acutely toxic – May be harmful, aspiration hazard
Skin irritant	
6.3A	Substances that are irritating to the skin
6.3B	Substances that are mildly irritating to the skin
Eye irritant	
6.4A	Substances that are irritating to the eye
Sensitisation	
6.5A	Substances that are respiratory sensitisers
6.5B	Substances that are contact sensitisers
Mutagens	
6.6A	Substances that are known or presumed human mutagens
6.6B	Substances that are suspected human mutagens
Carcinogens	
6.7A	Substances that are known or presumed human carcinogens
6.7B	Substances that are suspected human carcinogens
Reproductive/developmental toxicants	
6.8A	Substances that are known or presumed human reproductive or developmental toxicants
6.8B	Substances that are suspected human reproductive or developmental toxicants
6.8C	Substances that produce toxic human reproductive or developmental effects on or via lactation
Target organ toxicants	
6.9A	Substances that are toxic to human target organs or systems
6.9B	Substances that are harmful to human target organs or systems
Skin corrosive	
8.2A	Substances that are corrosive to dermal tissue (UN PGI)
8.2B	Substances that are corrosive to dermal tissue (UN PGII)
8.2C	Substances that are corrosive to dermal tissue (UN PGIII)
Eye corrosive	
8.3A	Substances that are corrosive to ocular tissue

Source: www.epa.govt.nz/industry-areas/hazardous-substances/rules-for-hazardous-substances/hazardous-substances-classification-codes

Appendix 3: References

American Conference of Governmental Industrial Hygienists (ACGIH®). (2014). *Methyl Acrylate*. Chemical Substances 8th Edition Documentation. Cincinnati, Ohio: ACGIH®. From ACGIH®, Documentation of the Threshold Limit Values and Biological Exposure Indices, 8th Edition. Copyright 2020. Reprinted with permission.

Australian Industrial Chemicals Introduction Scheme (AICIS). (2014). *2-Propenoic acid: Human health tier II assessment*. www.industrialchemicals.gov.au/sites/default/files/2-Propenoic%20acid%2C%20methyl%20ester_Human%20health%20tier%20II%20assessment.pdf

Deutsche Forschungsgemeinschaft (DFG). (2019). *Methyl acrylate/Methyl prop-2-enoate*. The MAK-Collection for Occupational Health and Safety 2019, Vol. 4, No. 2; pp 382-406. https://onlinelibrary.wiley.com/doi/pdf/10.1002/3527600418.mb9633e6319

Environmental Protection Authority (EPA). (2020). Chemical Classification and Information Database (CCID): *2-Propenoic acid, methyl ester*. www.epa.govt.nz/database-search/chemical-classification-and-information-database-ccid/view/7CB5CA79-9FDD-4D63-B613-959DC5197DBA

European Chemicals Agency (ECHA) Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). (2020). Dossier for Methyl acrylate accessed March 2020. https://echa.europa.eu/de/registration-dossier/-/registered-dossier/15313

Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA). (2020). GESTIS International Limit Values. Accessed January 2020 http://limitvalue.ifa.dguv.de

International Agency for Research on Cancer (IARC). (1999). *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 71: Re-Evaluation of Some Organic Chemicals, Hydrazine and Hydrogen Peroxide*. Lyon; pp 1489-1496.

National Institute for Occupational Safety and Health (NIOSH). (1994). *Manual of Analytical Methods (NMAM)*. Methyl Acrylate. Issue 1. www.cdc.gov/niosh/docs/2003-154/pdfs/1459.pdf

National Library of Medicine (NLM) PubChem database accessed March 2020: Compound Summary – *Methyl acrylate*. https://pubchem.ncbi.nlm.nih.gov/compound/Methyl-acrylate

National Toxicology Program (NTP) Report on Carcinogens (RoC). (14th Edition, 2016). Accessed March 2020. https://ntp.niehs.nih.gov/pubhealth/roc/index-1.html

SafeWork Australia. (2019). *Methyl acrylate – draft evaluation report WES*. https://engage.swa.gov.au/52961/documents/128692

WorkSafe New Zealand. (2020). Special guide *Workplace Exposure Standards and Biological Exposure Indices* (12th Ed.) November 2020. worksafe.govt.nz/topic-and-industry/work-related-health/monitoring/exposure-standards-and-biological-exposure-indices

Notes

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