Workplace Exposure Standard (WES) review

HYDROGEN CYANIDE
(CAS NO: 74-90-8)

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Te Kāwanatanga o Aotearoa
New Zealand Government

WORKSAFE
Mahi Haumaru Aotearoa

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Terms that are **bold** (first occurrence only) are further defined in the Glossary.

Summary

	CURRENT	PROPOSED
WES-TWA	–	1 **ppm** (1 **mg/m³**)*
WES-STEL	–	–
WES-Ceiling	10 ppm (11 mg/m³)	5ppm (5mg/m³)*
Notations	***skin***	*skin* ***oto***

* As cyanide (**CN^-**)

TABLE 1: Current and proposed Workplace Exposure Standard (**WES**) for hydrogen cyanide

Recommendation and basis for WES

It is proposed that WorkSafe:

1. adopt a WES-TWA for hydrogen cyanide of 1 ppm (1 mg/m³ as cyanide ion, CN^-)
2. adopt a WES-Ceiling for hydrogen cyanide of 5 ppm (5 mg/m³ as cyanide ion, CN^-)
3. maintain the *skin*; notation for hydrogen cyanide
4. adopt an ***oto*** notation for hydrogen cyanide.

To protect for neurological effects, thyroid damage and respiratory tract irritation.

Discussion

Hydrogen cyanide is used to fumigate enclosed spaces; in petroleum refining, electroplating and metallurgy; and, as a chemical intermediate (**SCOEL**, 2010; **ACGIH®**, 2001).

The odour of hydrogen cyanide is reported as bitter almond, with a threshold reported at 1-5 ppm in air. However, many people cannot perceive the odour at all (**PubChem**, 2020; ACGIH®, 2001; SCOEL, 2010).

Hydrogen cyanide and the cyanide salts, such as potassium (CAS: 151-50-8), sodium (CAS: 143-33-9) and calcium (CAS: 592-01-8) all express their toxic potential through the release of the cyanide ion (CN^-).

NIOSH have established an **IDLH** concentration for hydrogen cyanide at 50 ppm, based on acute inhalation toxicity data in humans (NIOSH, 1994).

Cancer risks

Neither the International Agency for Research on Cancer (**IARC**, 2020) nor the US National Toxicology Program (**NTP**) Report on Carcinogens (**RoC**), Fourteenth Edition (NTP RoC, 2016) have an evaluation on the carcinogenic potential of hydrogen cyanide.

SCOEL

The Scientific Committee on Occupational Exposure Limits (SCOEL) review of hydrogen cyanide noted that the critical effects of inhalation exposure were neurological effects, thyroid damage and respiratory tract irritation (SCOEL, 2010).

The SCOEL recommended an OEL, 8-hour **TWA** of 1 mg/m³ and a **STEL** of 5mg/m³ for CN^- from any combination of hydrogen, potassium and sodium cyanides, with a skin notation for all three substances (SCOEL, 2010). The 8-hour TWA of 1 mg/m³ was based on a **LOAEL** of 4.7mg CN^-/m³ from the epidemiological study of El Ghawabi *et al*. (1975 cited in SCOEL, 2010) with a factor 5 for the extrapolation

from the LOAEL to the **NAEL**. The basis of the STEL of 5mg/m^3 was not explicitly stated, although SCOEL noted the steep dose-response relationship and the severity (lethal) of acute effects in humans (SCOEL, 2010).

The SCOEL review also noted the very high skin permeability measured for hydrogen cyanide and cyanide ions, and recommended a skin notation (SCOEL, 2010).

DFG

The Deutsche Forschungsgemeinschaft (**DFG**, German Research Foundation) re-evaluation of hydrogen cyanide noted that the critical long-term effects were neurological and thyroid damage (DFG MAK, 2003).

The DFG based the **MAK** value of 2 mg CN^-/m^3 (inhalable fraction), **peak limitation Category II** with an excursion factor of 2, on a NOAEL of 1.6 **mg/kg b.w./day** from a 13-week study in rats, and a cyanide detoxification capacity in humans reported as 0.1 to 1.0 mg/kg b.w. per hour (DFG MAK, 2003). An 8-hour shift exposure to the MAK value of 2 mg/m^3, assuming 100% absorption, inhalation of 10 m^3, and 70 kg b.w., would lead to a dose of 0.28 mg/kg b.w., giving a margin to the lowest reported cyanide detoxification capacity of 0.8 mg/kg b.w. per 8-hour shift (DFG MAK, 2003).

The DFG noted that an excursion factor of 2 was appropriate, as brief peaks at acutely toxic concentrations could be detoxified (DFG MAK, 2003).

The DFG noted an **"H"** notation was warranted for hydrogen cyanide, based on dermal absorption through human skin (*in vitro* study) and reported rapid systemic toxicity after exposure to aqueous hydrogen cyanide solutions (DFG MAK, 2003). A **Pregnancy Risk Group C** designation was also assigned (DFG MAK, 2003).

The DFG noted no **"Sa"** or **"Sh"** designations for hydrogen cyanide, based on lack of data (DFG MAK, 2003).

ACGIH

The American Conference of Governmental Industrial Hygienists' (ACGIH®) review of hydrogen cyanide and cyanide salts noted that the critical effects were neurological effects, respiratory tract irritation and thyroid enlargement (ACGIH®, 2001).

The ACGIH® review concluded that:

> "The previous **TLV-Ceiling** of 10 ppm for **HCN** was reduced to a TLV-Ceiling of 4.7 ppm (5 mg/m^3), as CN, to provide a greater margin of safety against acute poisoning and to minimize the risk to exposed workers of throat irritation, headache, and symptoms resulting from chronic exposure to cyanide such as thyroid enlargement. Because HCN may be rapidly absorbed through the skin in lethal amounts (NIOSH, 1997), the **Skin** notation is retained.
>
> "It is generally accepted that HCN and cyanide salts act by the same mechanism, namely the release of cyanide ion (Hartung, 1994)." (References cited in ACGIH®, 2001).

The ACGIH® review also noted that sufficient data were not available to provide the basis for recommending **SEN** or carcinogenicity notations (ACGIH®, 2001).

Safe Work Australia

In their draft proposal, Safe Work Australia has recommended:

- an 8-hour TWA of 0.9ppm (1mg/m^3) for hydrogen cyanide to protect for chronic neurological symptoms and thyroid enlargement in exposed workers
- a peak limitation of 4.7ppm (5mg/m^3) was also recommended to protect for immediate and severe health effect (death, coma, respiratory failure) in workers exposed at the workplace, and
- an "Sk" (skin) notation because evidence indicates rapid absorption through the skin. (Safe Work Australia, 2019).

Conclusions

Based on the documentation cited and informed by the conclusions of the SCOEL, DFG and ACGIH® reviews, WorkSafe considers its current WES-Ceiling for hydrogen cyanide of 10ppm (11mg/m^3), to be inadequate to manage health risks from possible workplace exposure.

It is recommended for hydrogen cyanide that a WES-TWA of 1ppm (1mg/m^3) as CN^- and a WES-Ceiling of 5ppm (5mg/m^3) as CN^- be adopted to protect against neurological effects, thyroid damage and respiratory tract irritation from acute and chronic inhalation exposures, based on the SCOEL recommendations.

Available data indicated that the ***skin*** notation should be maintained, but that a ***sen*** notation was not warranted for hydrogen cyanide.

Hydrogen cyanide and its salts are known ototoxins (OSHA, 2018; Campo *et al*., 2013).

Appendix 1: Additional information

Glossary	Definition of terms used in this document – see Appendix 2
Physicochemical properties	https://pubchem.ncbi.nlm.nih.gov/compound/Hydrogen-cyanide#section=Chemical-and-Physical-Properties
CAS Number	74-90-8
Conversion factors	1 mg/m³ = 0.91 ppm (25°C; 101.3 kPa) 1 ppm = 1.10 mg/m³ (25°C; 101.3 kPa)
Exposure standards from around the world	http://limitvalue.ifa.dguv.de
HSNO Classification	Sodium cyanide www.epa.govt.nz/database-search/chemical-classification-and-information-database-ccid/view/B594DD80-95F9-462B-86FA-B5E010A949B6 Potassium cyanide www.epa.govt.nz/database-search/chemical-classification-and-information-database-ccid/view/CF9C8415-247B-4FE3-95B0-185AD369134E

References: PubChem 2020; **IFA**, 2020; EPA, 2020

Appendix 2: Glossary

TERM	MEANING
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#
Ceiling or Ceiling Limit Value	Ceiling Limit Value – absolute exposure limit that should not be exceeded at any time.
CN^-	Cyanide ion.
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.
HCN	Hydrogen cyanide.
IARC	The International Agency for Research on Cancer – an agency of the World Health Organisation.
IDLH	Immediately dangerous to life or health air concentration values (IDLH values) developed by the National Institute for Occupational Safety and Health (NIOSH).
IFA	Institut für Arbeitsschutz der Deutschen Gestzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance).
LOAEL	Lowest Observed Adverse Effect Level.
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. A value set by the DFG.
mg/kg b.w./day or mg/kg bw/day or mg/kg/day or mg/kg bw/d	Milligram of substance per kilogram body weight per day (exposure rate).
mg/m^3	Milligrams of substance per cubic metre of air.
NAEL	No Adverse Effect Level.
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.
NTP	National Toxicology Program, US Department of Health and Human Services.
oto	Ototoxic. The substance may alone, or in concert with noise, result in hearing loss.
Peak limitation category 2/II	Substances with systemic effects; Excursion factor = 2 (default); Duration 15 minutes, average value; Number per shift = 4; Interval = 1 hour. A DFG term.
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.
PubChem	PubChem is an open chemistry database at the National Institutes of Health (NIH).
RoC / ROC	Report on carcinogens.
"Sa"	Sensitising to airways. A DFG MAK notation.

TERM	MEANING
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 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*.
"Sk"	SCOEL designation: short-hand for Skin notation. OR, depending on context: Skin notation – a notation indicating that absorption through the skin may be a significant source of exposure. A Safe Work Australia term.
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.
TLV-Ceiling	TLV® – Ceiling: the concentration that should not be exceeded during any part of the working exposure. If instantaneous measurements are not available, sampling should be conducted for the minimum period of time sufficient to detect exposures at or above the ceiling value. An ACGIH® term. Please see the Statement of Position Regarding the TLVs® and BEIs® and Policy Statement on the Uses of TLVs® and BEIs®
TWA	Time-weighted average exposure.
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-Ceiling	A concentration that should not be exceeded at any time during any part of the working day.
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 3: References

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Notes

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